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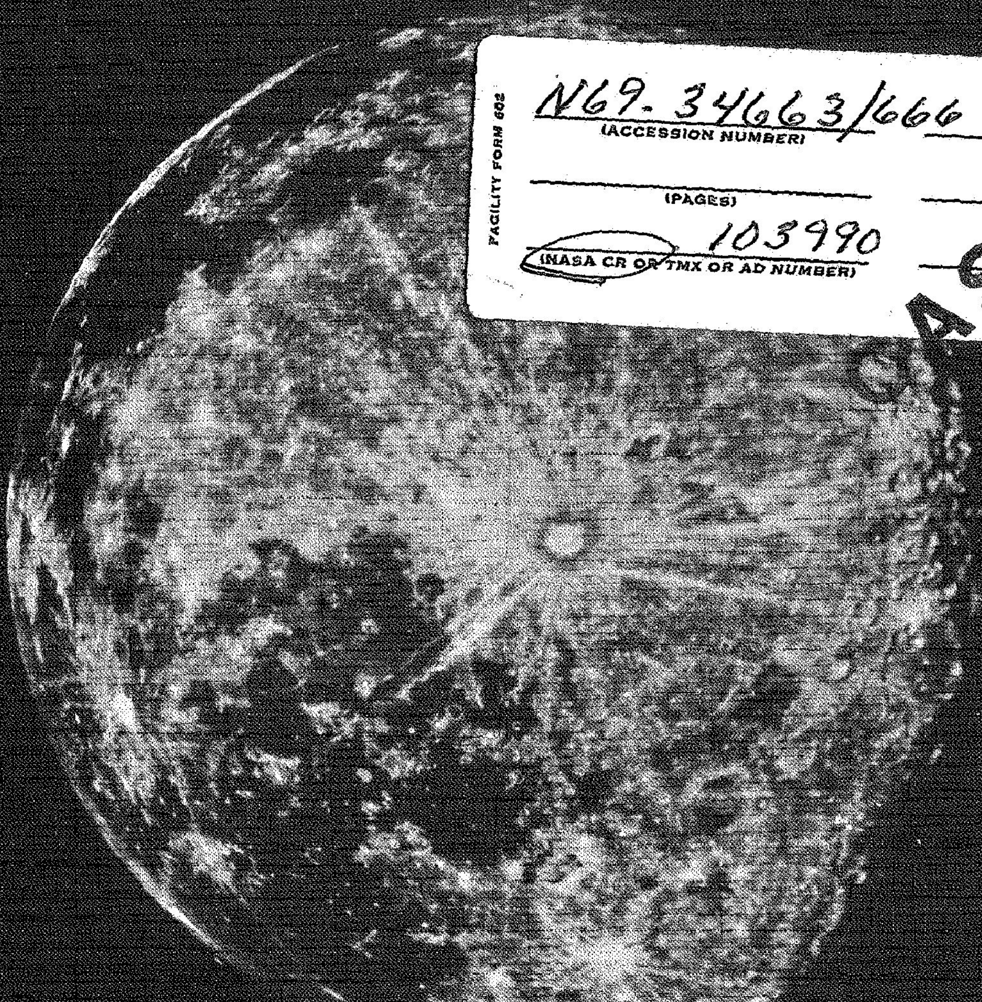
Communications Nos. 160–162



Volume 9 Part 1

THE UNIVERSITY OF ARIZONA

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LUNAR AND PLANETARY LABORATORY

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Communications of the Lunar and Planetary Laboratory

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The University of Arizona Tucson, Arizona	GERARD P. KUIPER, *Director* *Lunar and Planetary Laboratory*

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No. 160 ARIZONA-NASA ATLAS OF INFARED SOLAR SPECTRUM REPORT IV

by L. A. Bijl, G. P. Kuiper, and D. P. Cruikshank

February 1, 1969

ABSTRACT

This paper is a continuation of *Comm. LPL* Nos. 123 and 124, covering the interval λλ 13138–14707 Å. Part of the spectrum of the 1.4 μ H_2O band taken with the 4-meter spectrometer in flight is included to show the absorption in the spectrometer itself. For purposes of further identification, laboratory spectra of the 1.4 μ H_2O band are given in the Addendum.

This paper gives Charts 15c–22 of the Solar Spectrum Atlas. It concludes the section recorded with the 1200 lines/mm grating, the earlier parts having been published in *Comm. LPL* Nos. 123 and 124. Starting at λ 12188 Å (and thus providing overlap), the solar spectrum was recorded with 600 lines/mm gratings, up to λ 30500 Å. This second record also covers the gap of 281 Å (λλ 12857–13138 Å) occurring between Chart 15b (Fig. 9, *Comm. LPL* No. 124) and Chart 15c, the present Fig. 1; this gap was due to shortage of observing time on the August 6 flight. Data concerning Charts 15c–22 are found in Table 1.

As before, the spectral records were obtained by two of us (G. P. K. and D. P. C.); but in this paper the construction of the wavelength scale and the classification of the absorption lines were done entirely by L. A. B. The wavelength scale is based on Mohler's *Table of Solar Spectrum Wavelengths, λ 11984 to λ 25578 A*, with additional consultation of Courtoy's *Spectre Infrarouge à Grande Dispersion et Constantes Moleculaires du CO_2* for the lines in the $3\nu_3$ band of CO_2 at λ 1.43 μ. The greater part of our present scale is based on water-vapor lines, as Mohler's *Table* gives mainly water-vapor lines in this spectral region. His H_2O wavelengths were obtained, however, from very broad and strong lines even though his measurements were done on spectra containing less water vapor than shown in the *Michigan Photometric Atlas of the Infrared Solar Spectrum λ 8465 to λ 25242.* Since in our spectra the water-vapor lines are narrow, we have sometimes used instead the *predicted* wavelengths from Mohler's *Table*. The scale between λ 13180 Å and λ 13265 Å has been interpolated.

As in *Comm. LPL* Nos. 123 and 124, we have

TABLE 1

SOLAR SPECTRUM RECORDS, 4-M SPECTROMETER, NASA CV-990 JET

1 μ GRATING (1200 LINES/MM), SLIT AND CELL 0.10 MM, τ = 0.12 SEC, 1 μ FILTER

FIG.	CHART	λ (Å)	1968 DATE	UT	ALT. (FT.)	TEMP (°C)	CABIN ALT. (FT.)	GAIN
1	15. c	13138–13197	Aug 6	18:45	41,500	−58	8800	5–2
	d	13197–13257	Aug 6	18:48	41,500	−58	8800	5–2
2	16. a	13257–13314	Aug 6	18:51	41,500	−58	8800	5–2
	b	13314–13371	Aug 6	18:55	41,500	−58	8800	5–2
	c	13371–13428	Aug 6	18:58	41,500	−58	8800	5–2
	d	13428–13484	Aug 6	19:01	41,500	−58	8800	5–2
3	17. a	13484–13541	Aug 6	19:05	42,000	−58	8800	5–2
	b	13541–13597	Aug 6	19:08	42,000	−58	8800	5–2
	c	13597–13652	Aug 6	19:11	42,000	−58	8800	5–2
	d	13652–13708	Aug 6	19:15	42,000	−58	8800	5–2
4	18. a	13708–13762	Aug 6	19:18	41,500	−57	8800	5–2, 5–3
	b	13762–13816	Aug 6	19:21	41,500	−57	8800	5–3
	c	13816–13871	Aug 6	19:25	41,500	−57	8800	5–3
	d	13871–13924	Aug 6	19:28	41,500	−57	8800	5–3
5	19. a	13924–13976	Aug 6	19:31	41,500	−57	8800	5–3
	b	13976–14029	Aug 6	19:34	41,500	−57	8800	5–3
	c	14029–14079	Aug 6	19:38	41,300	−56	8800	5–3
	d	14079–14130	Aug 6	19:41	41,300	−56	8800	5–3
6	20. a	14130–14182	Aug 6	19:44	41,500	−57	8800	5–3
	b	14182–14231	Aug 6	19:48	41,500	−57	8800	5–3
	c	14231–14281	Aug 6	19:51	41,500	−57	8800	5–3
	d	14281–14331	Aug 6	19:54	41,500	−57	8800	5–3
7	21. a	14331–14379	Aug 6	19:58	41,500	−58	8800	5–3
	b	14379–14427	Aug 6	20:01	41,500	−58	8800	5–3
	c	14427–14477	Aug 6	20:04	41,500	−58	8800	5–3
	d	14477–14523	Aug 6	20:00	41,500	−58	8800	5–3
8	22. a	14523–14570	Aug 6	20:12	41,500	−59	8800	5–3
	b	14570–14618	Aug 6	20:15	41,500	−59	8800	5–3
	c	14618–14662	Aug 6	20:18	41,500	−59	8800	5–3
	d	14662–14707	Aug 6	20:21	41,500	−59	8800	5–3

TABLE 2

SOLAR LINES NOT RECORDED BEFORE, OR CLASSIFIED ATMOSPHERIC (*)

EQUIVALENT WIDTHS IN MÅ

λ	mÅ	λ	mÅ	λ	mÅ	λ	mÅ	λ	mÅ	λ	mÅ
13153.1	49	13546.3	64	13776.6*	38	13968.2*d*	46	14113.2	55	14437.7	28
13264.4*	39	13552.1	23	13790.3[1)]	20	13979.4	20	14121.3	66	14439.4	47
13285.7*	72	13564.7*	108	13828.3	21	13990.9	24	14123.7**d*	35	14460.7	19
13290.8	39	13581.3	54	13831.9	73	13996.1	88	14169.6	19	14465.7*	30
13291.6*	180	13588.2	15	13842.6	12	13998.0	106	14202.3	47	14478.9	21
13292.4	24	13589.2*d*	36	13849.7	52	14004.7	37	14211.2*	16	14498.1*	92
13297.5	88	13626.8	112	13864.2	107	14007.4	110	14213.5	18	14545.2	30
13321.3	110	13632.0*b*	114	13871.0	24	14026.7	42	14244.1	15	14548.8	41
13327.5*	117	13667.3	100	13873.2	17	14039.2	23	14275.7	34	14553.9*	14
13384.5	8	13693.8	158	13876.8	34	14040.2	9	14292.4	140	14566.5*	134
13389.5	72	13697.8*	37	13882.9*d*	38	14043.5*	25	14332.2*	28	14581.6	18
13432.4*	78	13711.7	140	13897.4	136	14060.8	37	14365.7*	23	14589.3*	25
13472.4	23	13722.6	39	13905.7	112	14073.6*	114	14370.3	10	14610.9	25
13494.8	28	13725.1	31	13940.1*	28	14081.0	26	14391.6	74	14654.4*	34
13499.4	20	13744.0	28	13957.0*	18	14081.5	46	14399.8	165	14658.3	13
13499.9	17	13756.0	177	13966.3	14	14084.1*d*	33	14403.4*	95	14679.9*	58
13502.0	125	13772.1	21	13967.2*	40	14099.7*	40	14420.3*	147	14703.1*b*	154

d = double line; *b* = blend with telluric line.

1) In Mich. catalog a 20 mÅ Ni line is given at λ 13791.35.

TABLE 3

LINES BEFORE LISTED AS ⊙ OR ⊙ ? BUT NOT PRESENT IN OUR RECORDS

λ (Å)	eq. width (mÅ)	λ (Å)	eq. width (mÅ)	λ (Å)	eq. width (mÅ)
13 233.75	27	13 493.90	42	14 385.48	43
13 239.56		13 890.06	21	14 481.82	30
13 360.68	16	13 891.25	21	14 559.56	11
13 427.28	68	13 891.64	55	14 669.61	28
13 471.21	109	13 900.78	18	14 695.52	41
13 478.84	14	13 929.14	18		

included the corresponding parts of the Michigan *Photometric Atlas* (Fig. 1M–8M). Comparing these spectra shows the tremendous advantage of high-altitude observations. Solar lines, previously masked by water-vapor absorptions or classified as "atmospheric," are listed in Table 2 (limited to lines with equivalent width $\geqslant$ 10 mÅ). Lines listed in the Mohler *Table* as "solar" or "probably solar," but absent is our spectra (and therefore probably telluric), are found in Table 3.

Unlike the 0.93 μ and 1.13 μ H_2O bands, the spectrometer absorptions of the 1.4 μ H_2O band are not entirely negligible. These absorptions may be estimated from the spectrum in Fig. A (corresponding in wavelength to the solar spectra, Figs. 4c, d and 5a, b). This spectrum was taken during the flight of August 6 before the solar observations; the aircraft altitude was 33,000 ft (41,500 ft for the solar observations) and the cabin pressure 6800 ft (8800 ft for the solar observations). As the spectrometer was flushed with outside air, both factors, especially the aircraft altitude, will have increased the strength of the H_2O comparison spectrum by a factor computed to be about 4 times for the weaker lines (depth < 0.3) and somewhat less for stronger lines. The equivalent widths of the lines in Fig. A are on the average about ⅔ of those of the water-vapor lines in the solar spectra; therefore, the equivalent widths in the cabin-spectrometer spectrum, if observed separately, would have been about 1/6 of those in the solar records, and this fraction would, for the weaker lines, be its contribution in the solar records. For strong lines the distortion caused by the inside water vapor will be less in the central portions of the lines; the extreme wings, however, will be largely due to the inside air (owing to its higher pressure). Also, the H_2O content may have varied during the record because some cirrus clouds were noted at the 33,000-ft level.

As before, a series of laboratory spectra were taken to match approximately the H_2O strength in the solar spectra. A representative set is reproduced in Figs. 2A–8A of the Addendum, which matches in wavelengths Figs. 2–8 of the text. They have assisted with the H_2O identifications in the solar records, as indicated by dots above the spectral traces. Members of the $3\nu_3$ band of CO_2 are similarly marked with short vertical lines; while all absorption lines in the solar record considered as real are marked with numbered dots below the spectral traces for later reference. The identification by element or the mere classification as solar, both taken from the Mohler *Table*, are added for the stronger lines (equivalent width $\geqslant$ 15 mÅ) on the charts.

Acknowledgments. We wish to thank Messrs. J. Percy, B. McClendon, A. Thomson, and Rev. G. Sill of LPL and Mr. D. Olsen of NASA-Ames for their assistance during the flights. Mrs. A. P. Agnieray and Mr. S. M. Larson assisted in the preparation of the figures. This research was supported by NASA through Grant NsG 161-61 and the University of Arizona Institutional Grant NGR-03-002-091.

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Mohler, O. C. 1955, *A Table of Solar Spectrum Wavelength, λ 11984A to λ 25578A*, Ann Arbor.

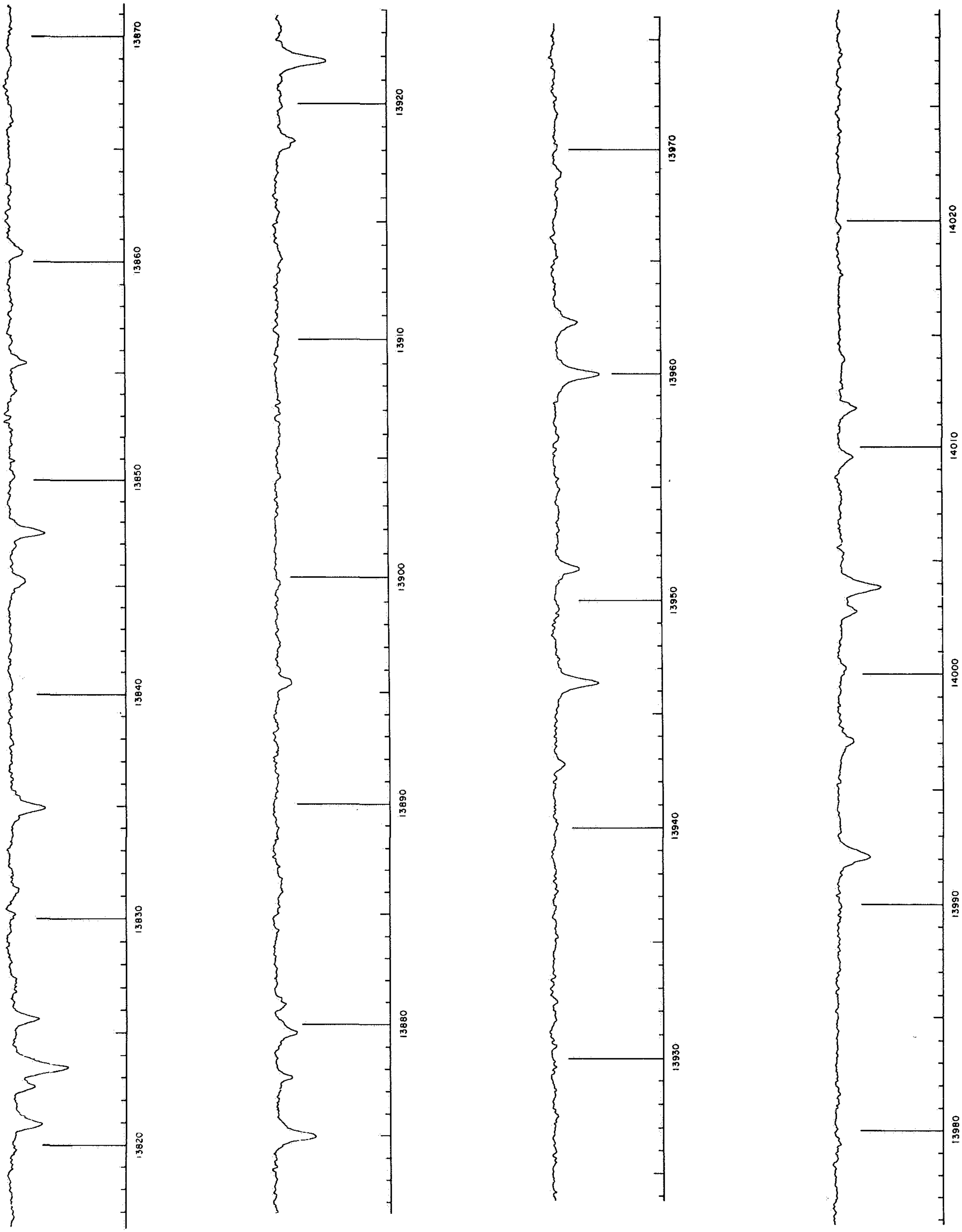

Fig. A Absorptions of water vapor in the spectrometer, λλ 13817–14029 Å, matching Figs. 4c, d, and 5a, b. For further explanation see text.

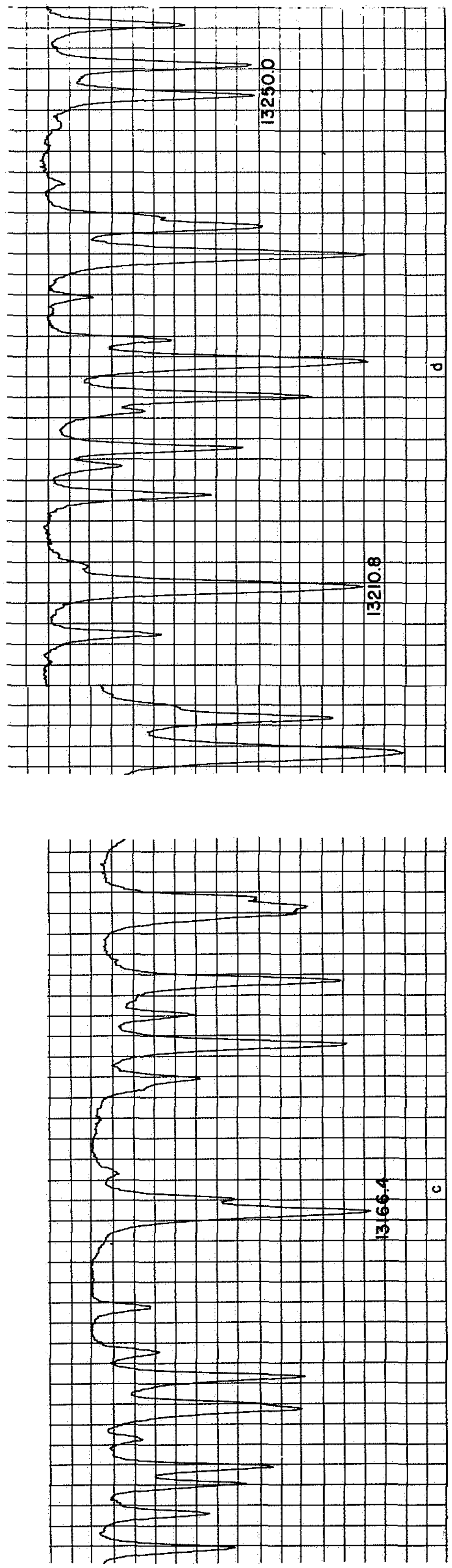

Fig. 1M Part of Michigan Atlas that matches Fig. 1 (1M–9M reproduced with permission.)

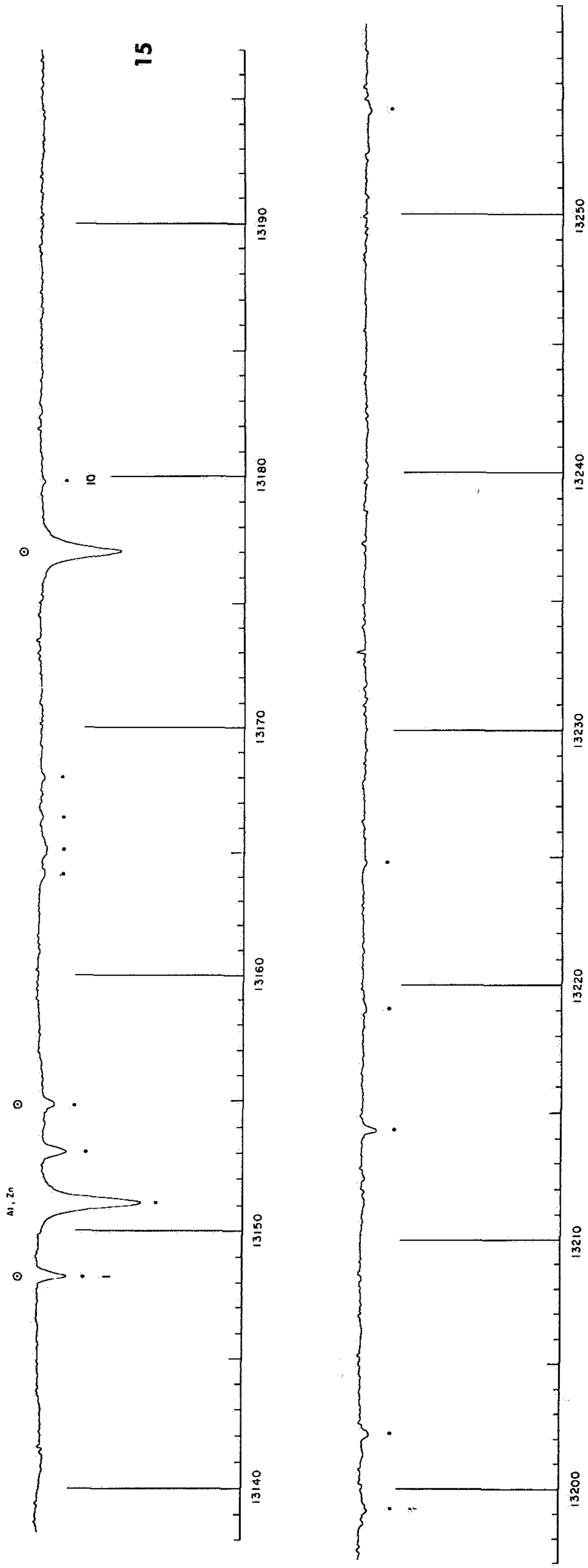

Fig. 1 Solar Spectrum λλ 13138–13257, in two strips (cf. Table 1).

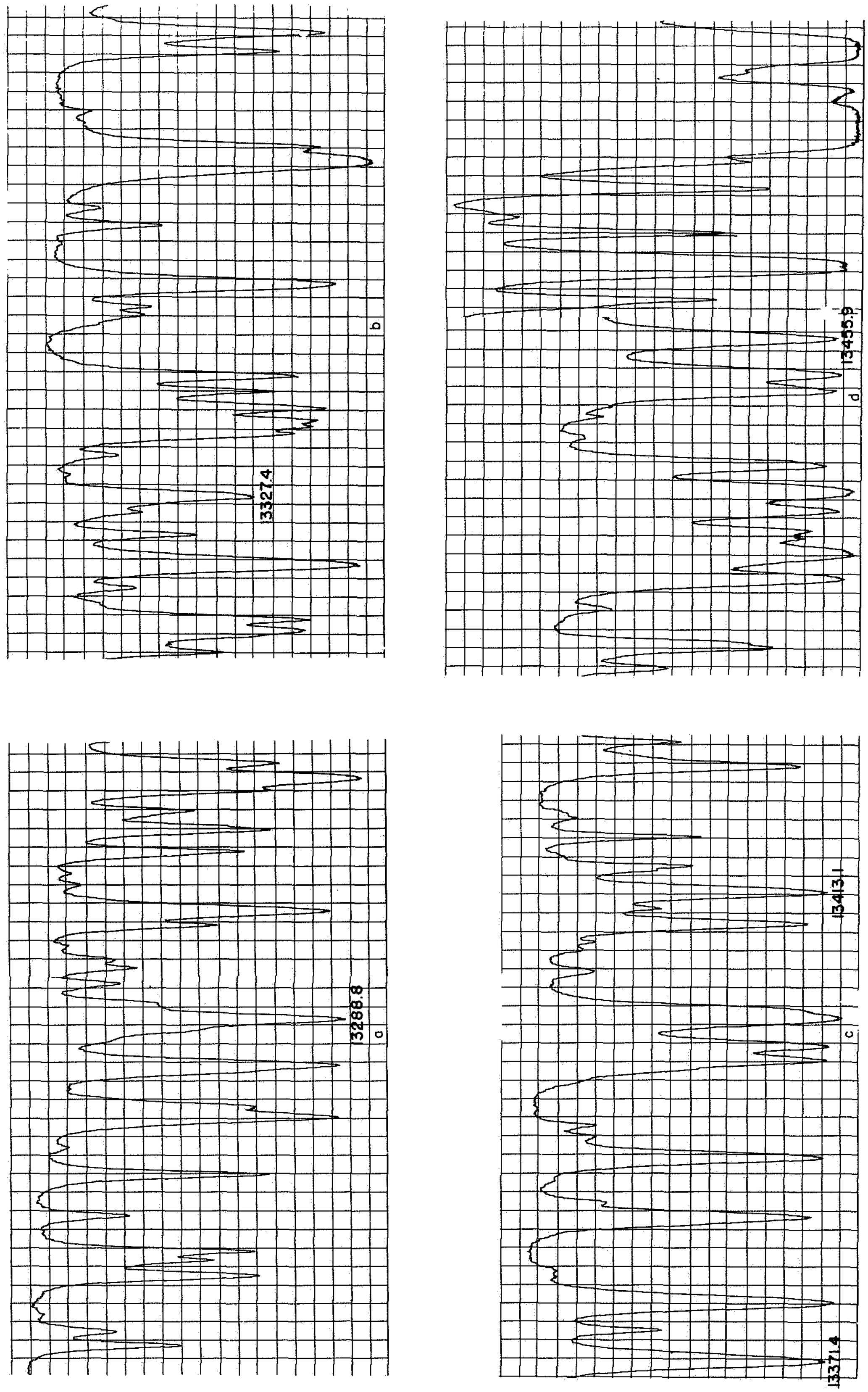

Fig. 2M Part of Michigan Atlas that matches Fig. 2.

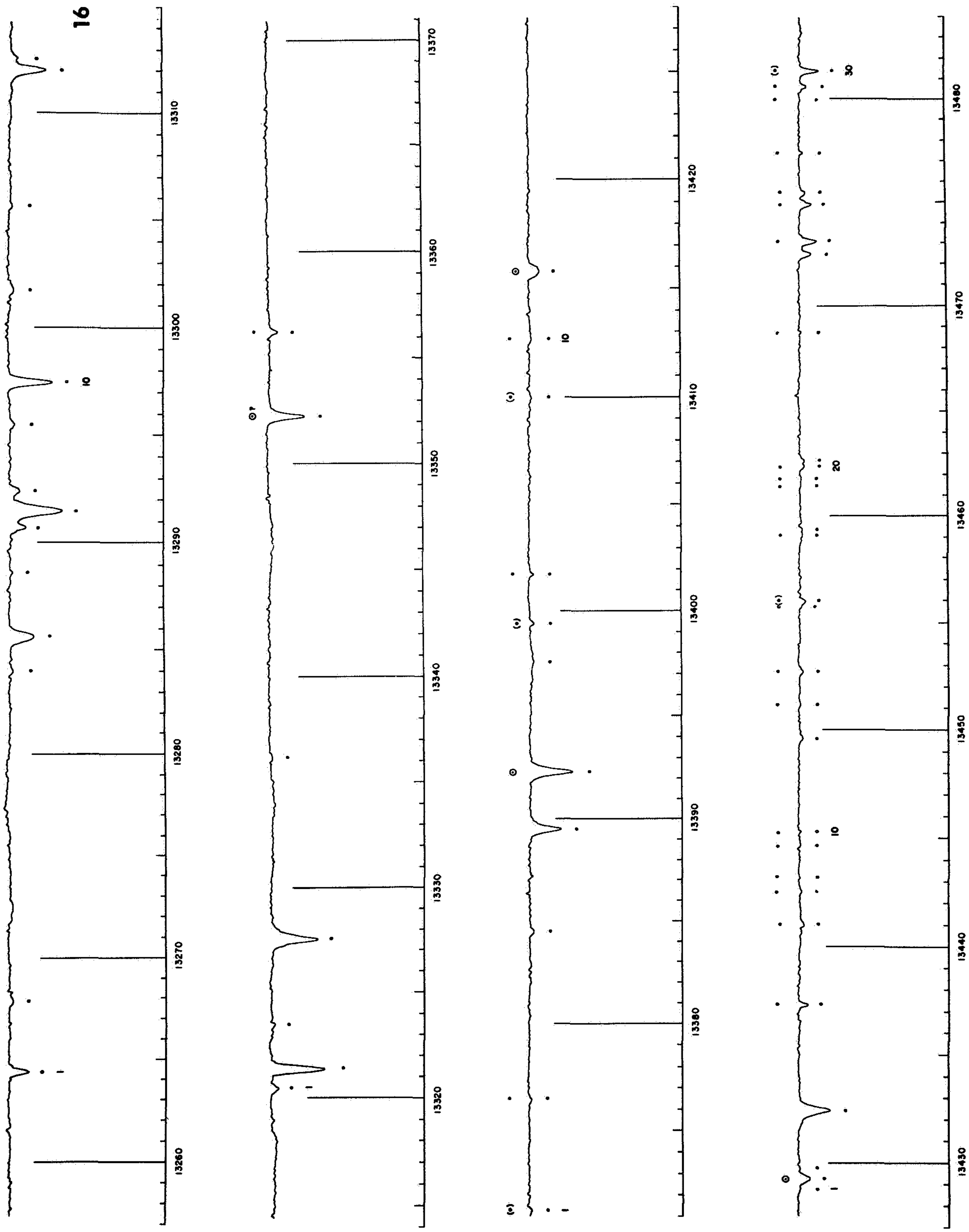

Fig. 2 Solar Spectrum λλ 13257–13484, in four strips (cf. Table 1).

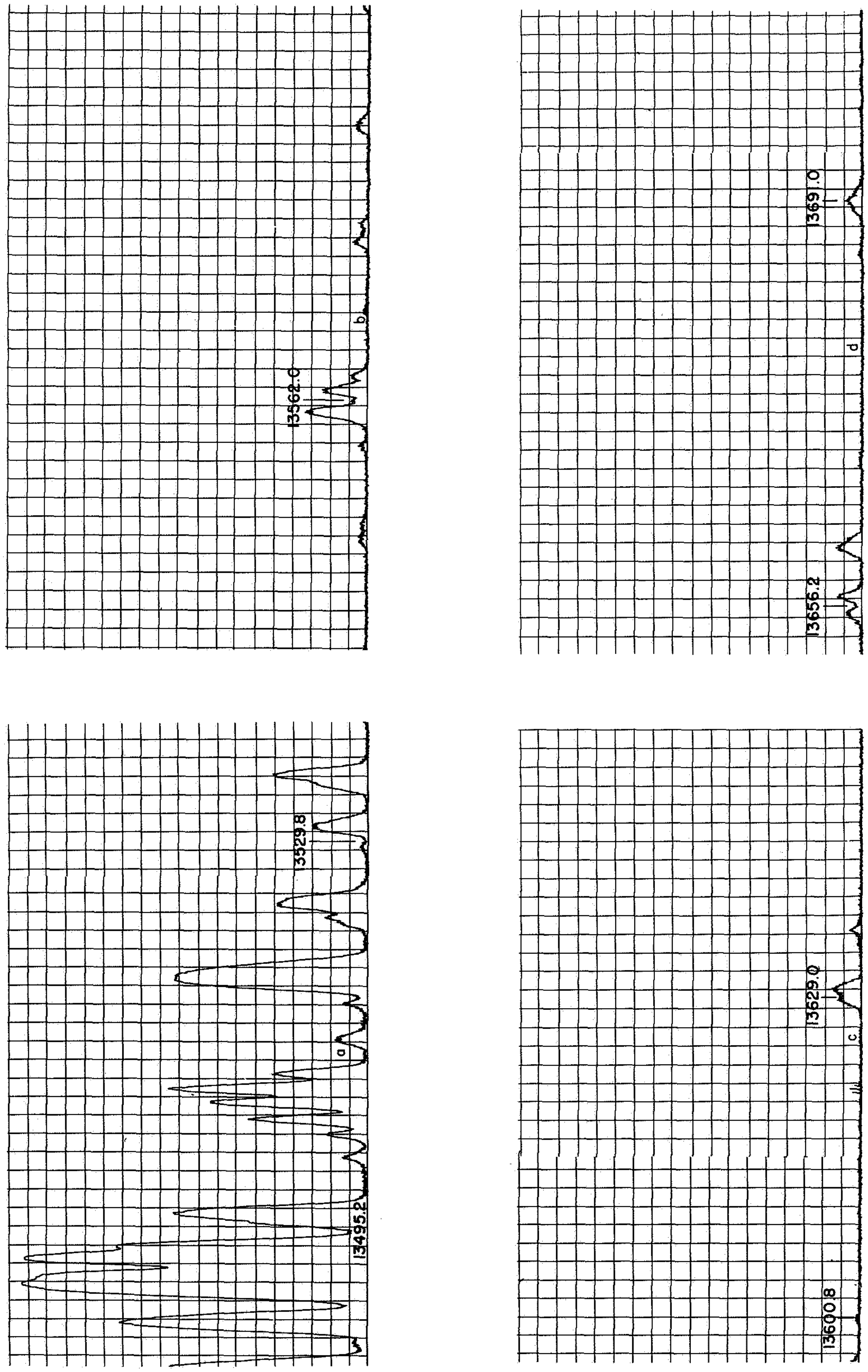

Fig. 3M Part of Michigan Atlas that matches Fig. 3.

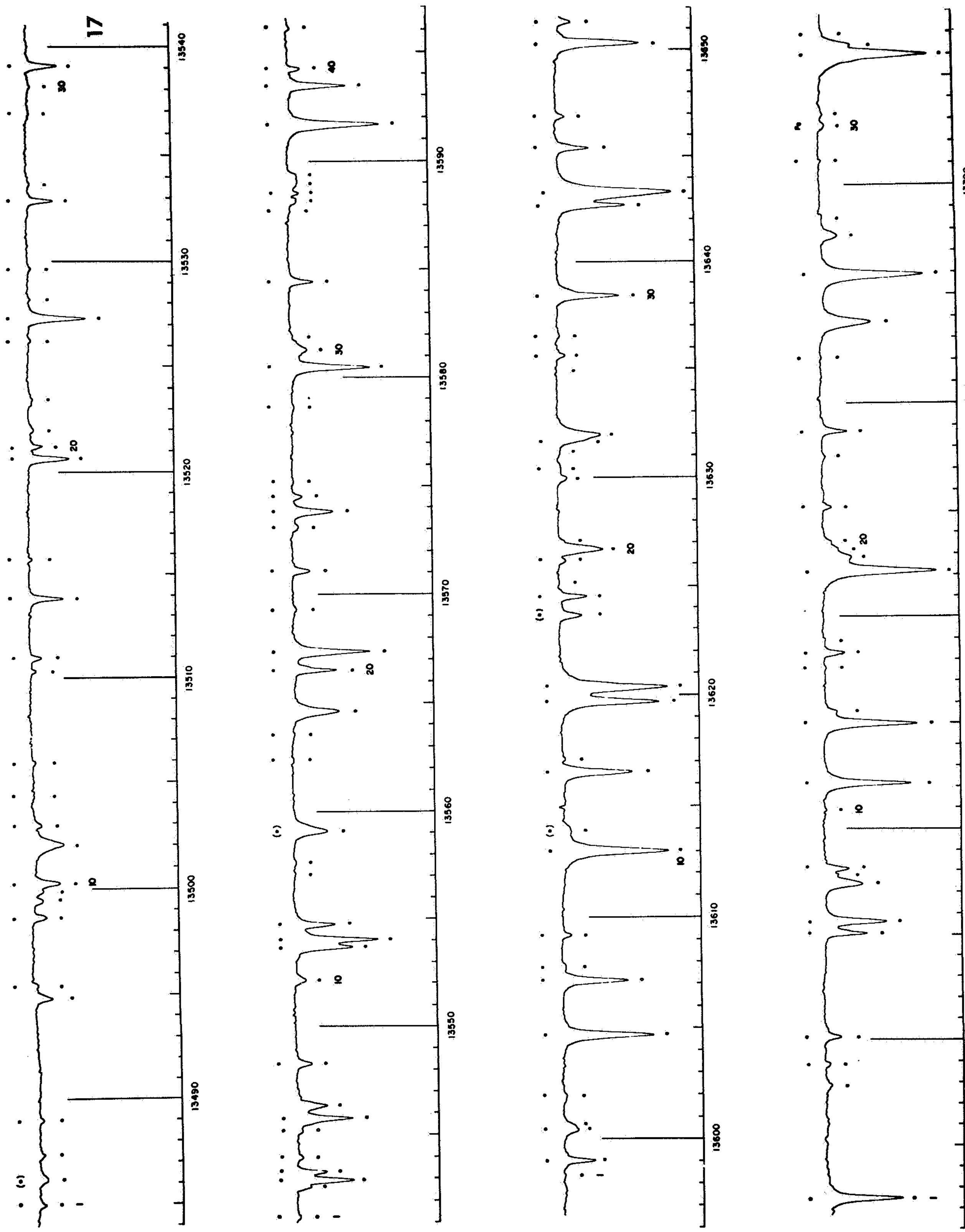

Fig. 3 Solar Spectrum λλ 13484–13708, in four strips (cf. Table 1).

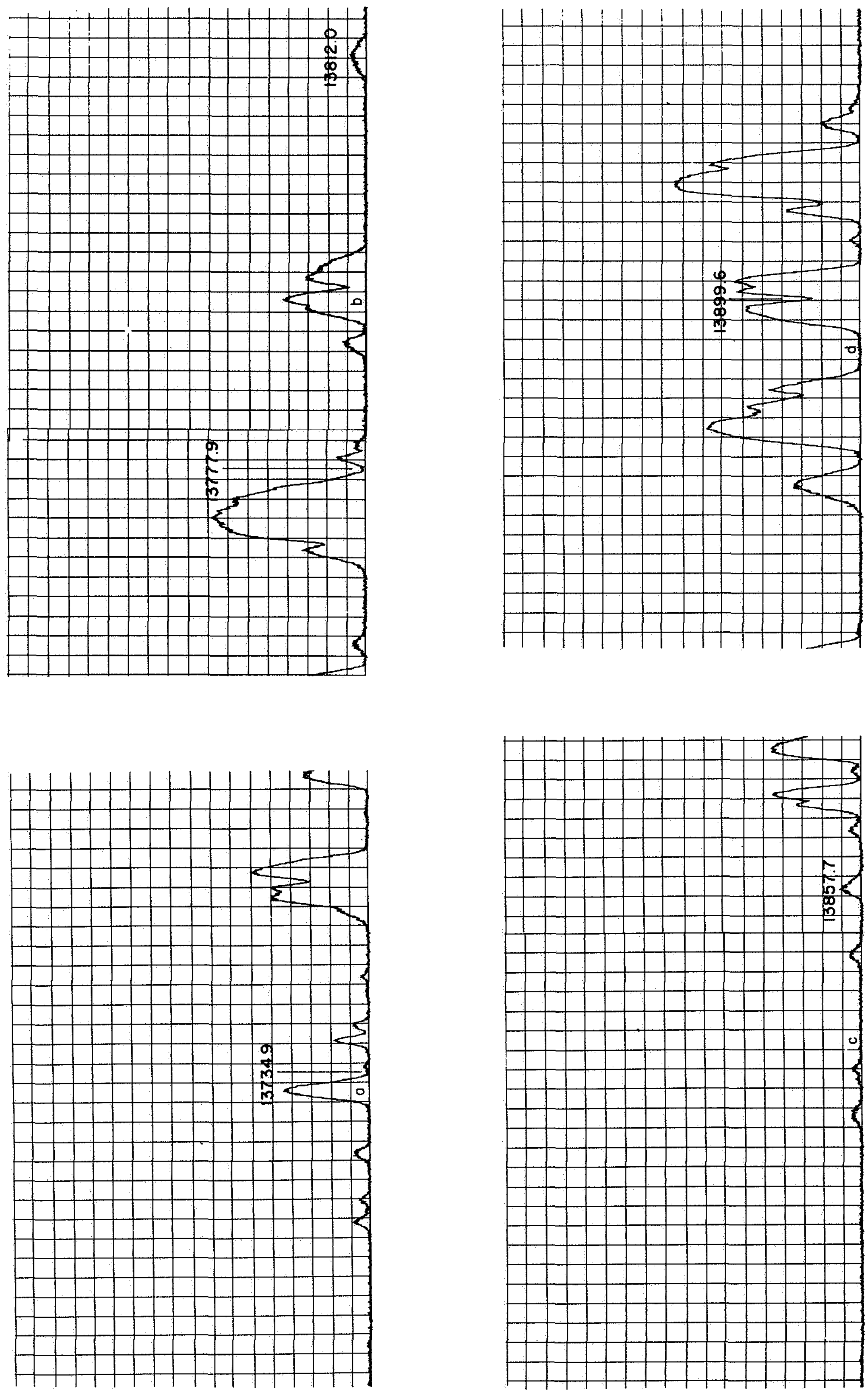

Fig. 4M Part of Michigan Atlas that matches Fig. 4.

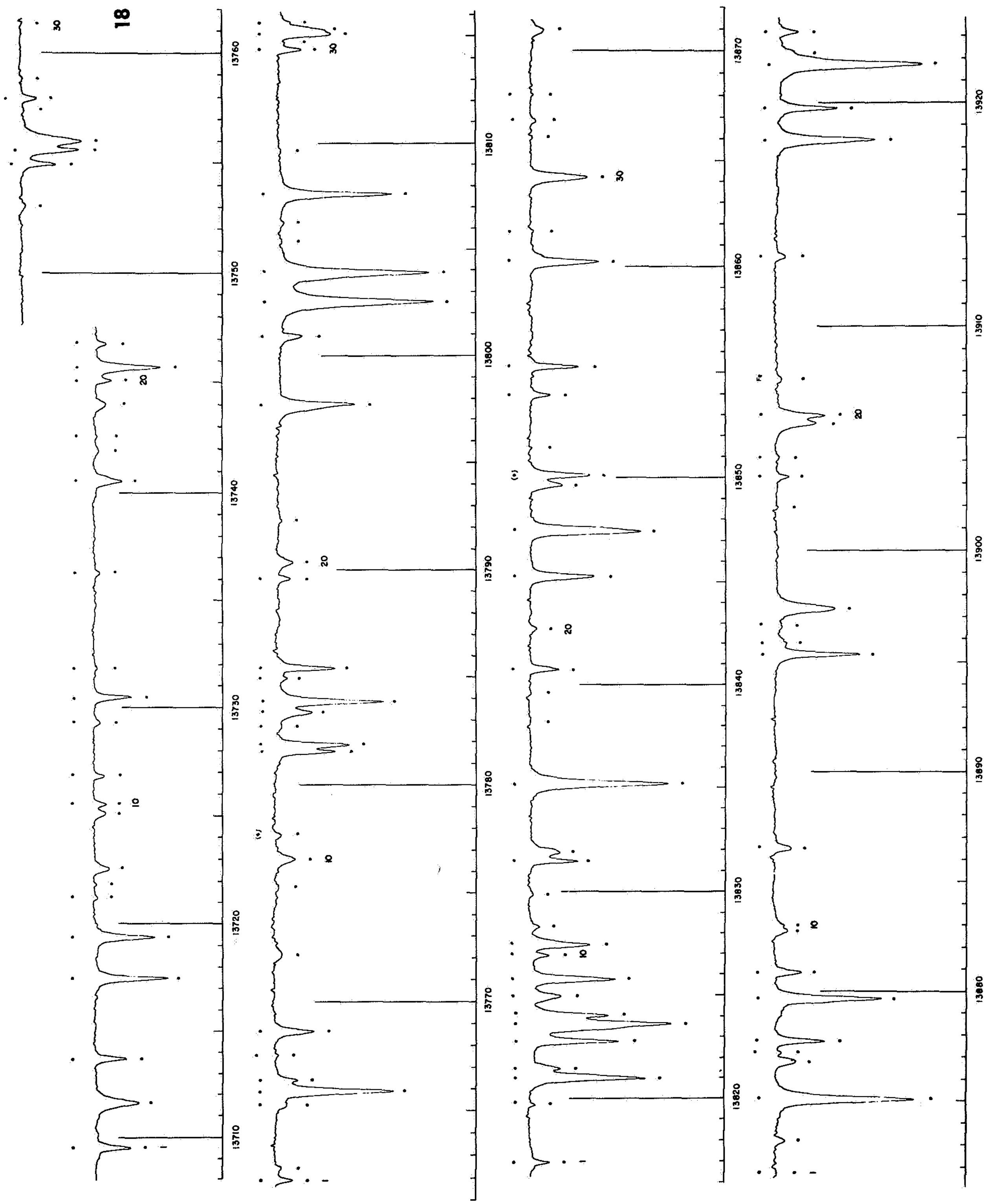

Fig. 4 Solar Spectrum λλ 13708–13924, in four strips (cf. Table 1).

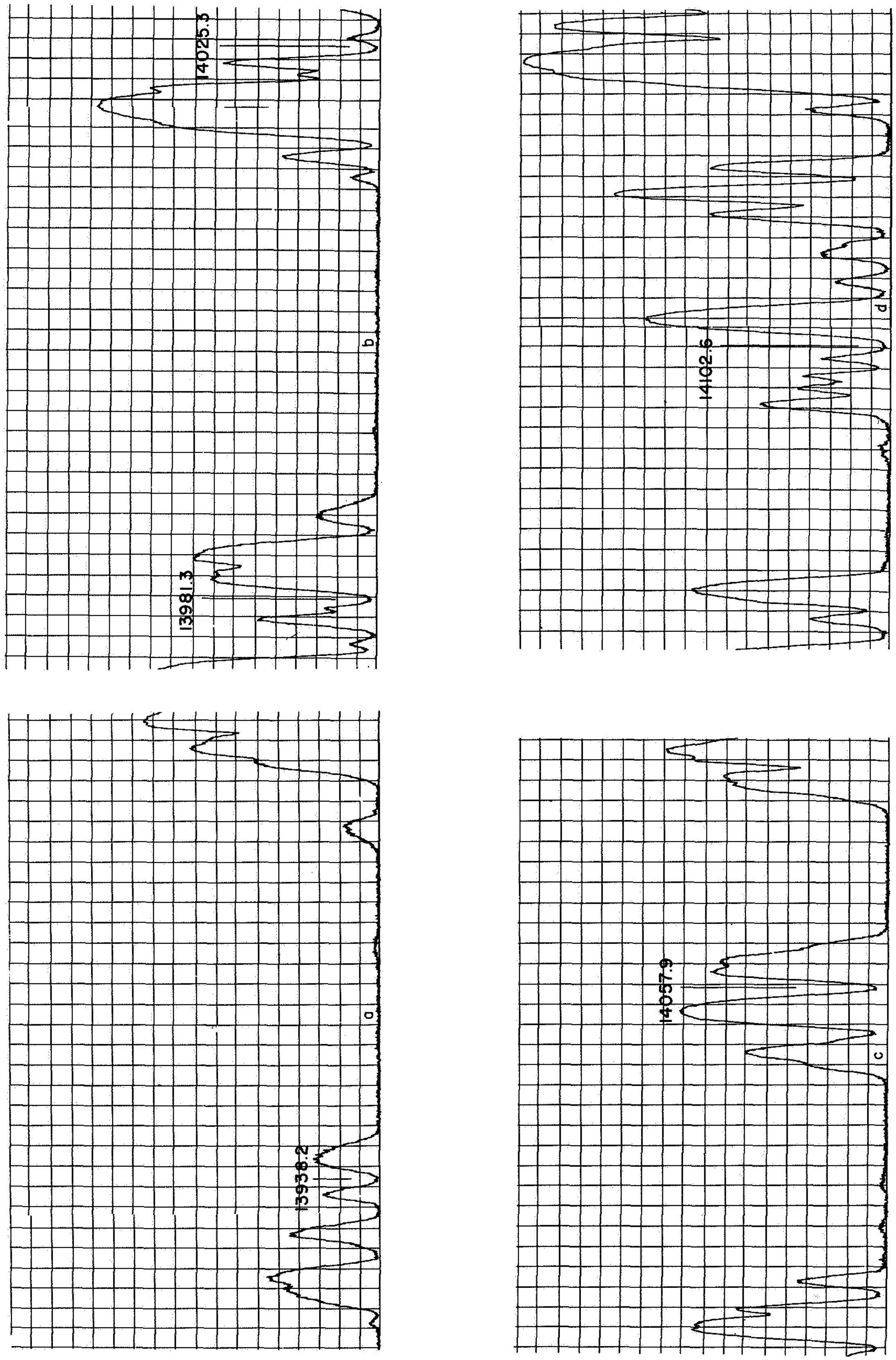

Fig. 5M Part of Michigan Atlas that matches Fig. 5.

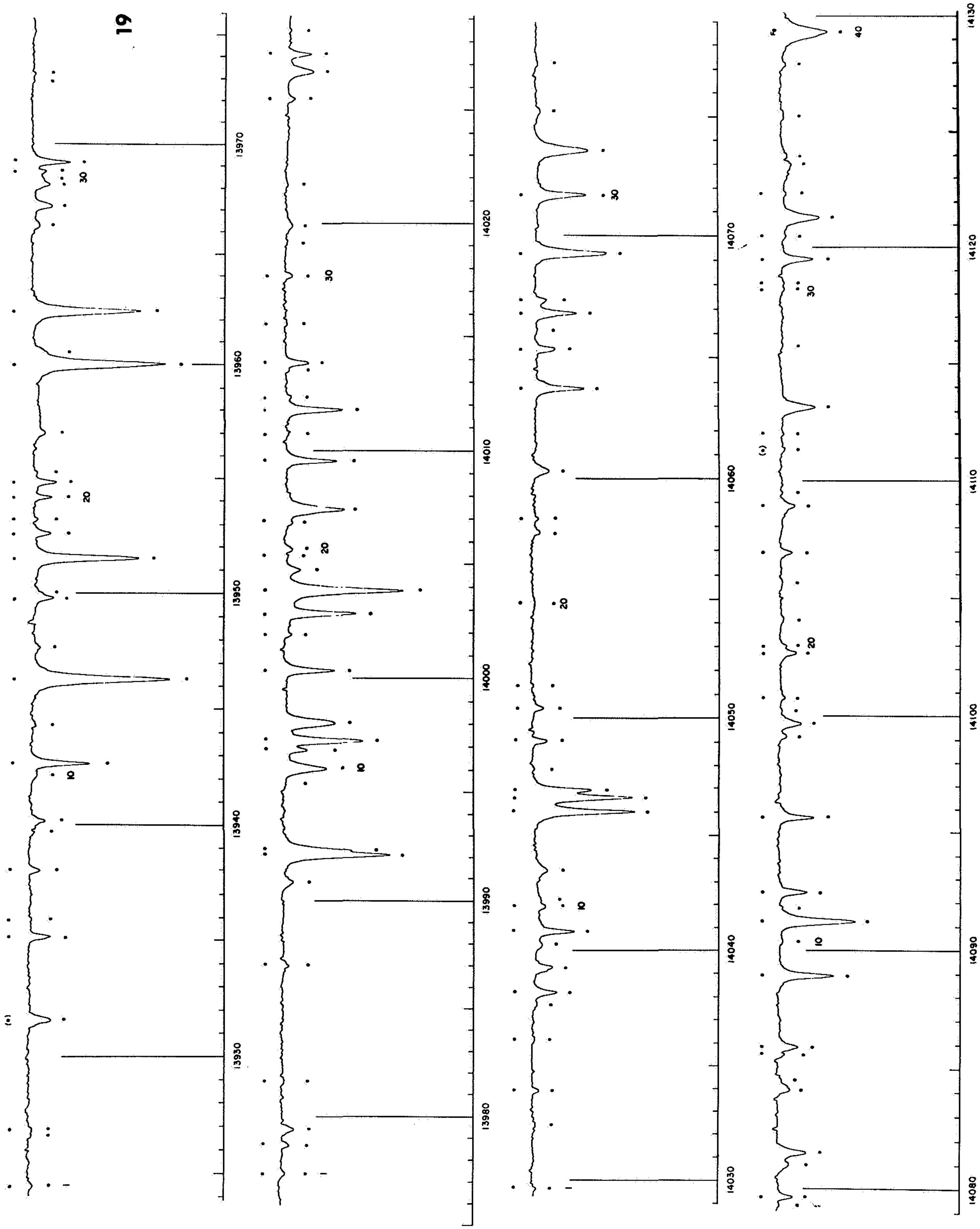

Fig. 5 Solar Spectrum λλ 13924–14130, in four strips (cf. Table 1).

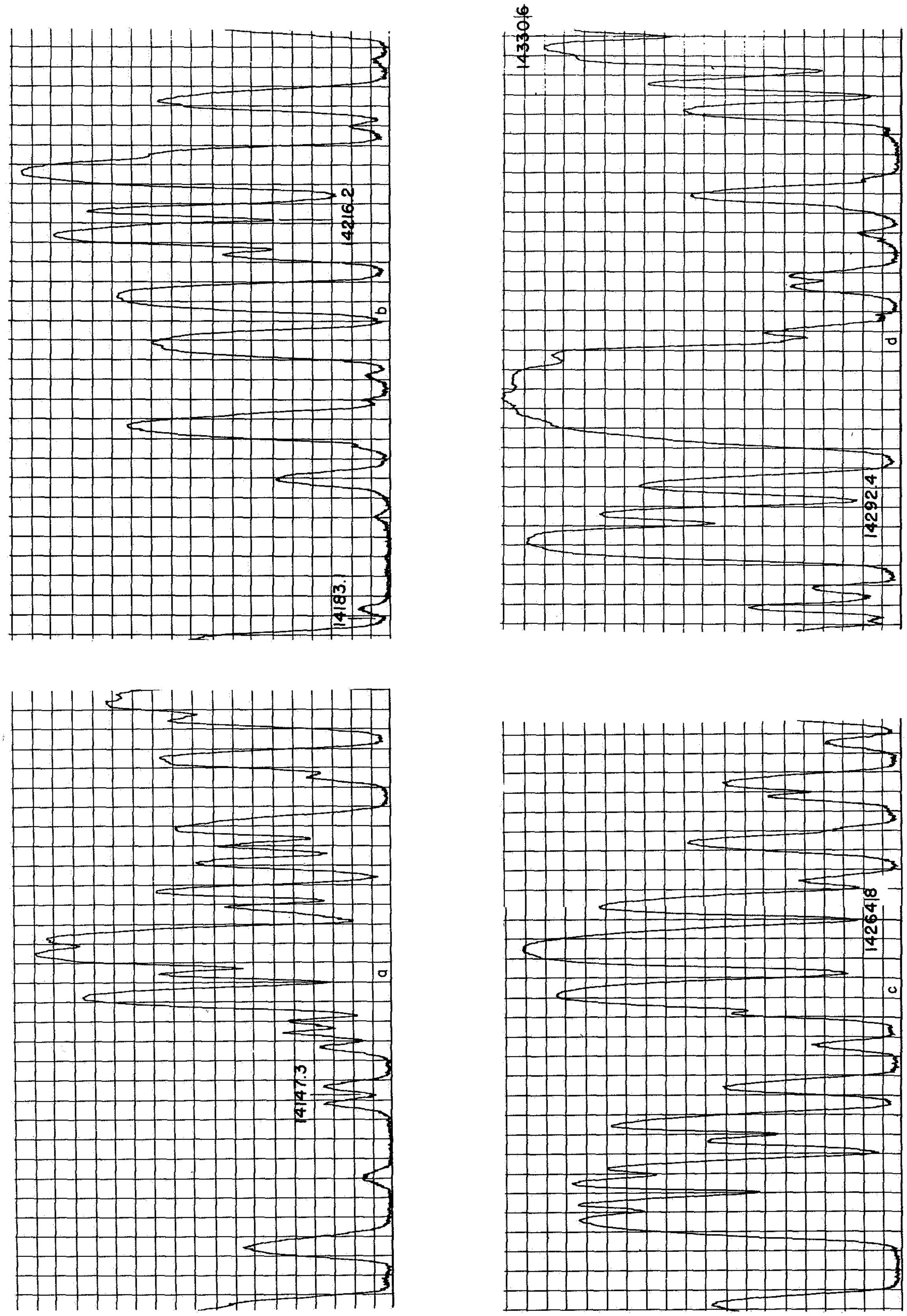

Fig. 6M Part of Michigan Atlas that matches Fig. 6.

Fig. 6 Solar Spectrum λλ 14130–14331, in four strips (cf. Table 1).

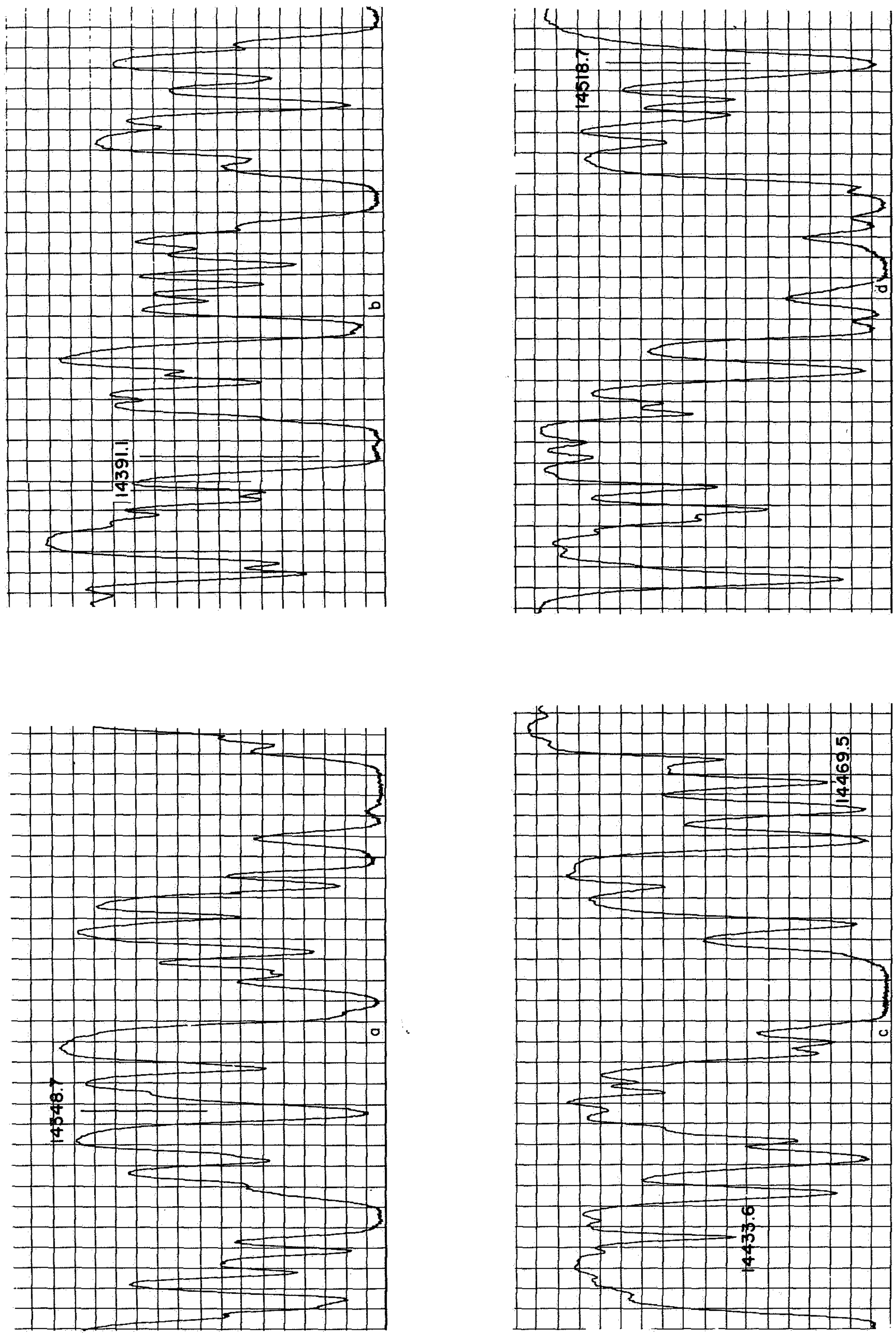

Fig. 7M Part of Michigan Atlas that matches Fig. 7.

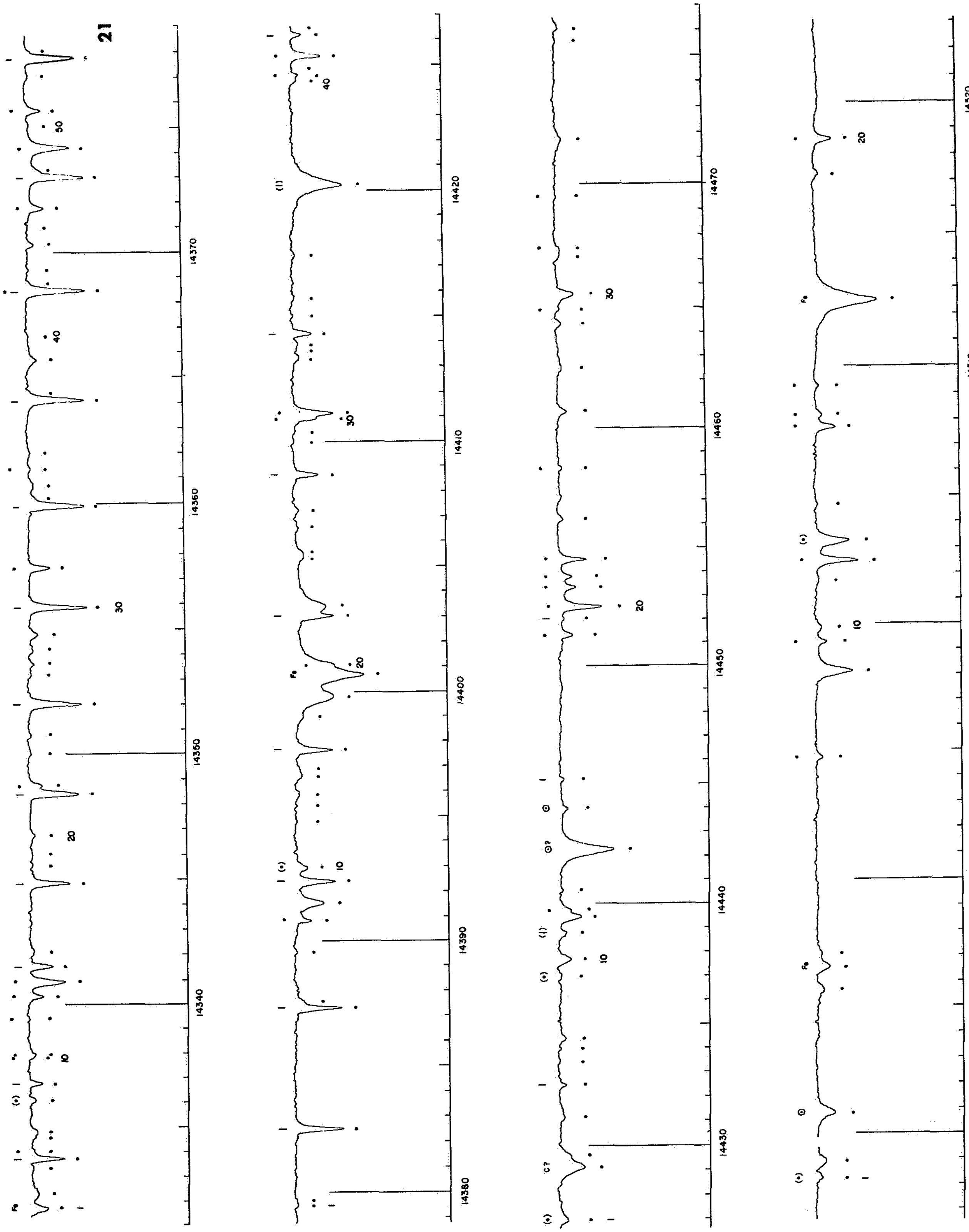

Fig. 7 Solar Spectrum λλ 14331–14523, in four strips (cf. Table 1).

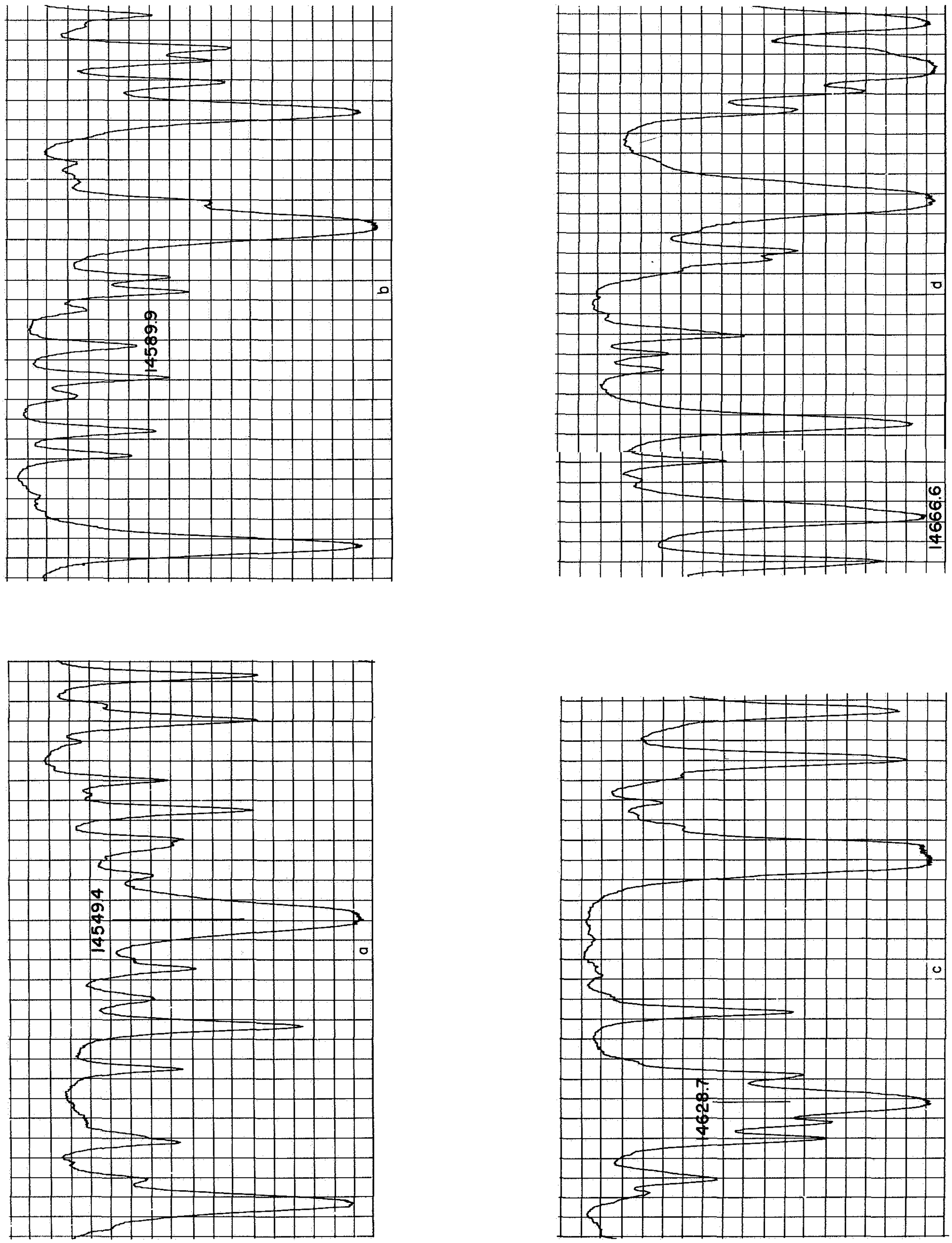

Fig. 8M Part of Michigan Atlas that matches Fig. 8.

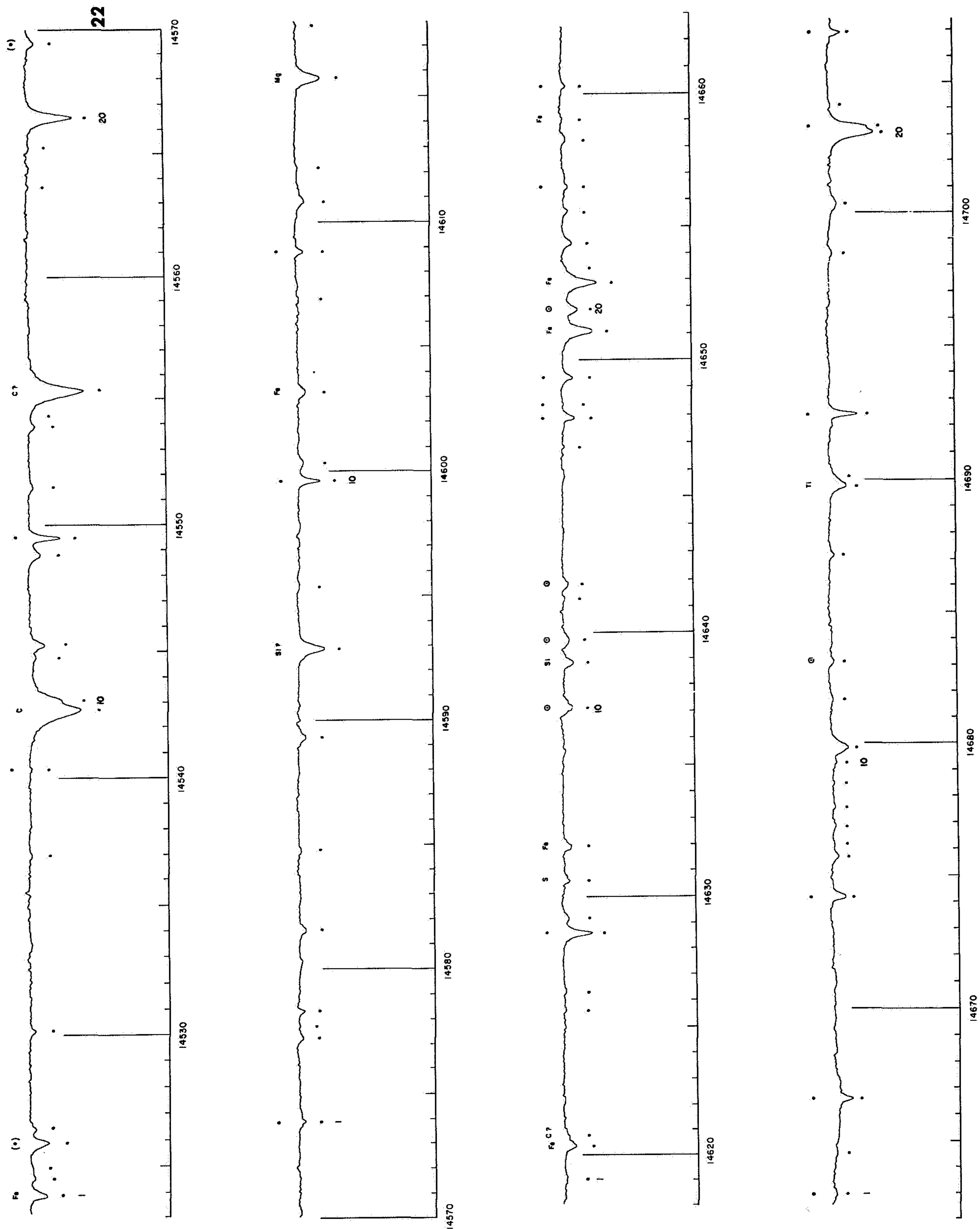

Fig. 8 Solar Spectrum λλ 14523–14707, in four strips (cf. Table 1).

ADDENDUM

SPECTRUM OF THE 1.13μ H_2O BAND

by LAURENS A. BIJL

In this Addendum, laboratory spectra are reproduced of the 1.4 μ H_2O band. They were made with the 4-m LPL spectrometer together with several runs not reproduced. All absorptions shown are due to water vapor in the ambient air. The 4-m spectrometer itself was flushed with dry nitrogen, although not completely dried out, with the absorptions adjusted to the desired level.

This laboratory spectrum shows strong line-broadening compared to the solar spectrum, due to the increased pressure. Lines, clearly resolved in the solar spectrum, are sometimes hardly seen as a blend in the laboratory spectra.

The slit-width and detector-size used in the laboratory runs were the same as in the solar flights. The scanning rate, however, was made 5 times slower (and the time-constant 5 times longer) to reduce the noise level that apparently resulted from the incandescent lamp. A Corning 2540 filter ($> 1\ \mu$) was used, as in the solar records.

The grating drive was readjusted after the solar flights, so that the phase of the small periodic error in dispersion does not match the solar spectrum (as may be seen from the wavelength scale).

The wavelength scale was based on the observed and predicted wavelengths of Mohler's (1955) *Table*.

Mrs. A. P. Agnieray and Mr. S. M. Larson assisted in the preparation of the figures.

REFERENCE

Mohler, O. C. 1955, *A Table of Solar Spectrum Wavelengths* λ *11986A to* λ *25578A*, Ann Arbor.

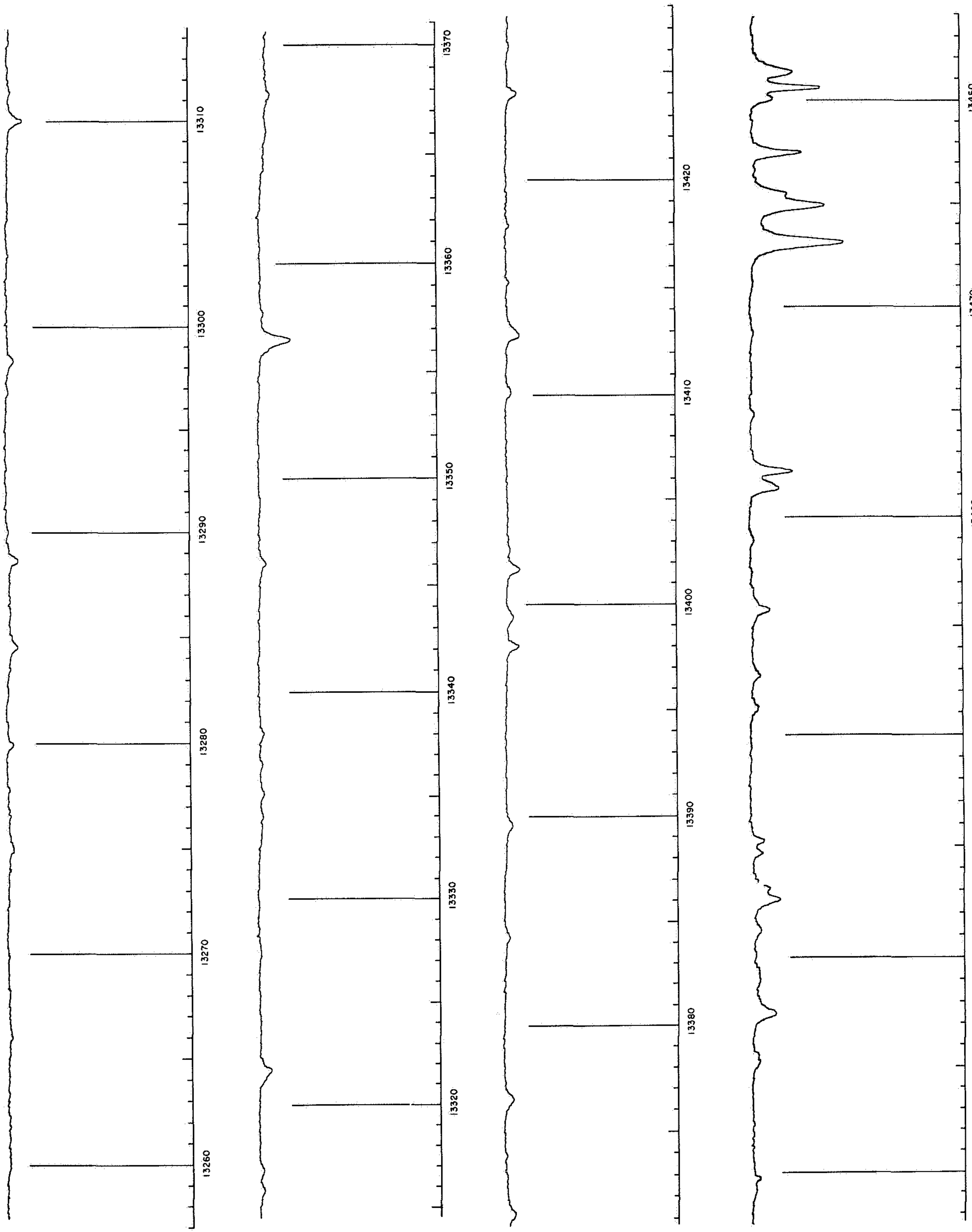

Fig. 1A Laboratory spectrum of water vapor, λλ 13257–13484 Å.

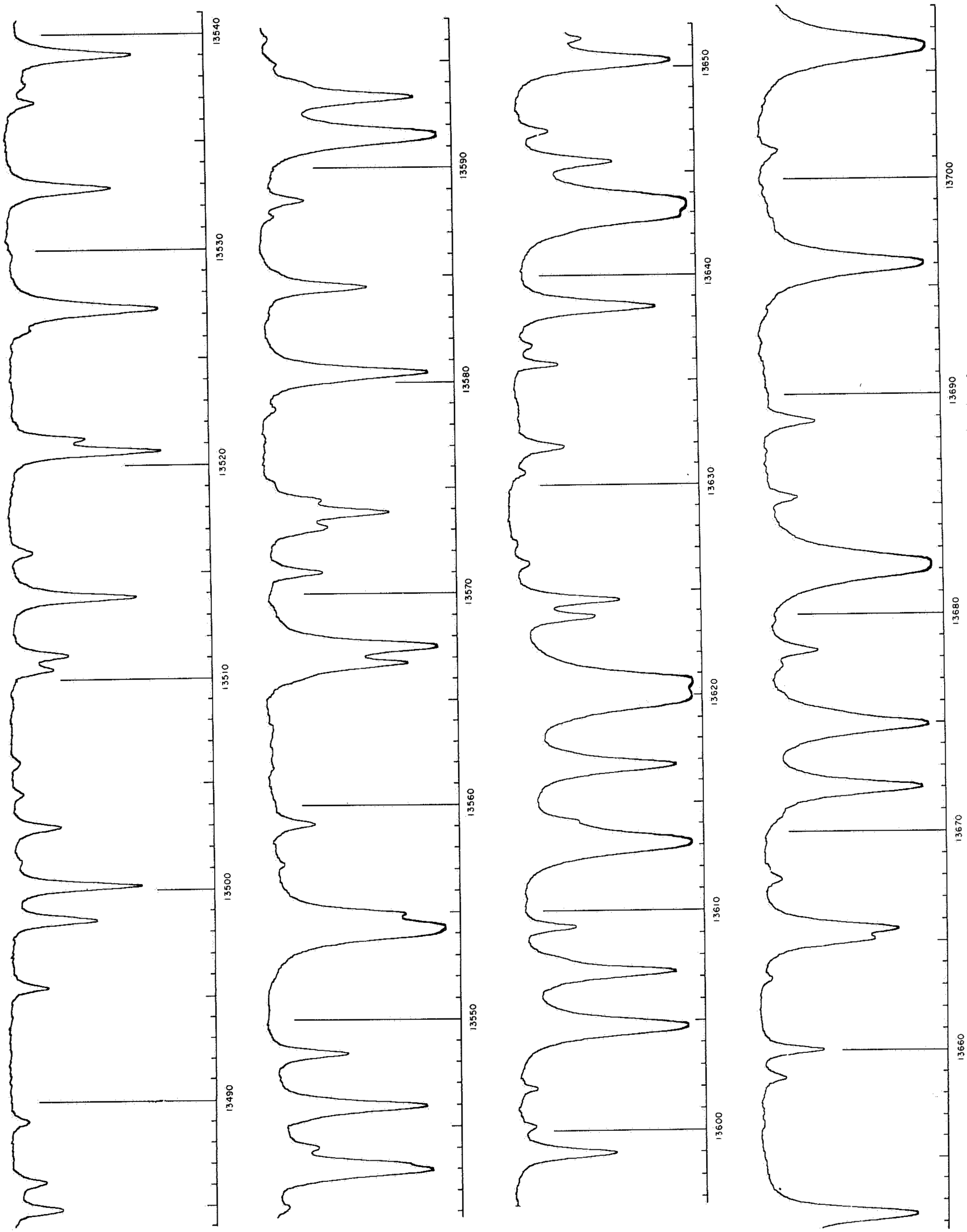

Fig. 2A Laboratory spectrum of water vapor, λλ 13484–13708 Å.

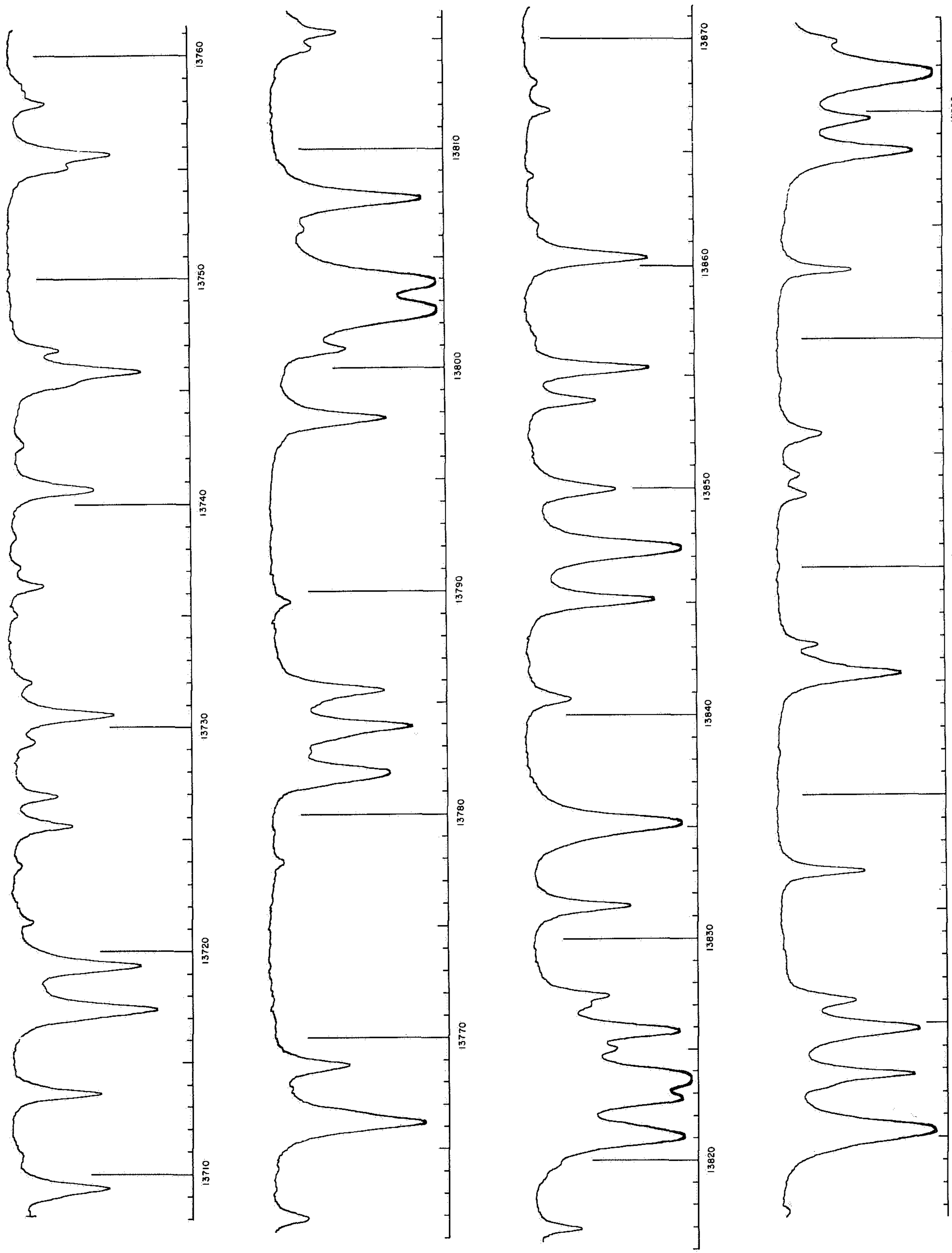

Fig. 3A Laboratory spectrum of water vapor, λλ 13708–13924 Å.

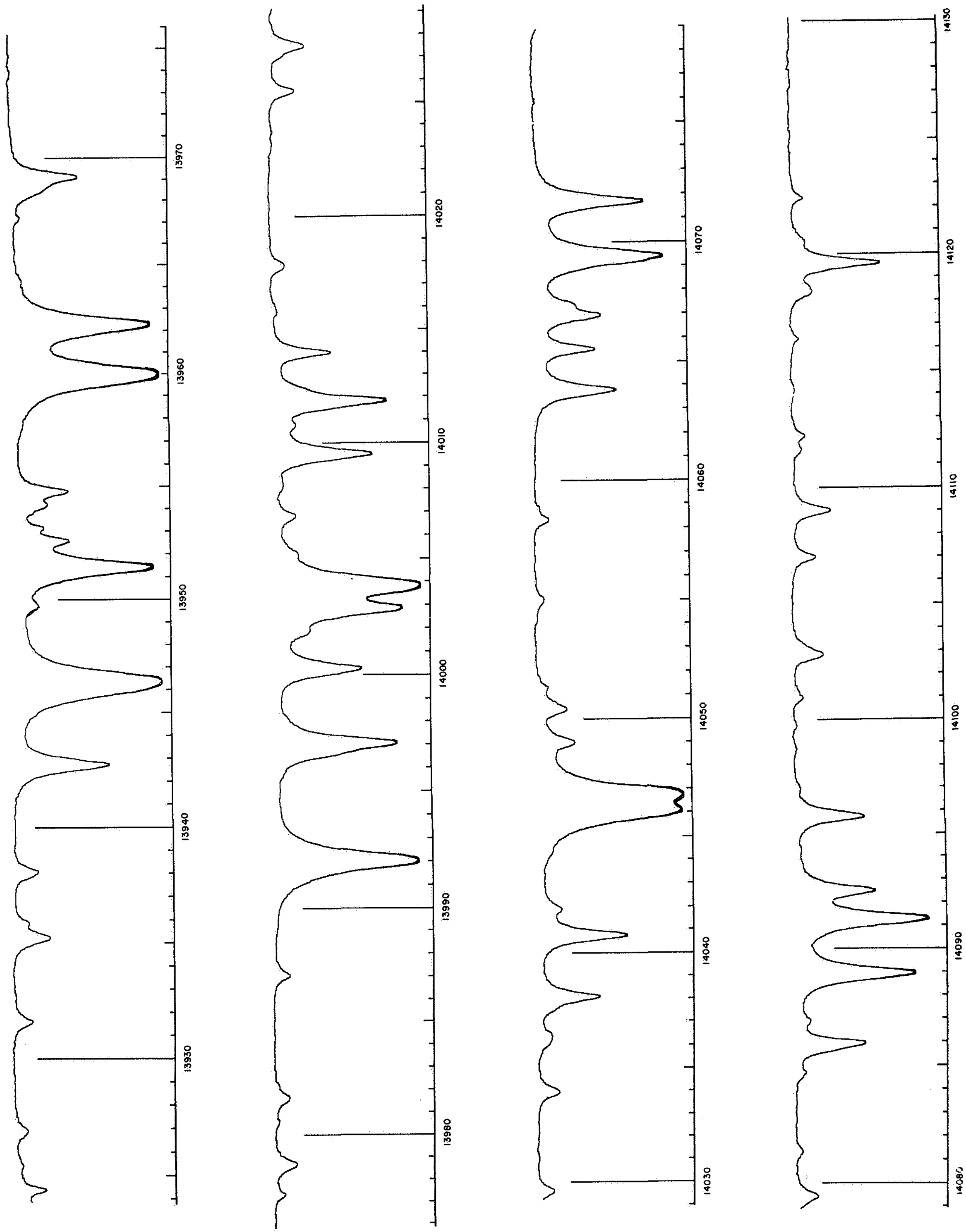

Fig. 4A Laboratory spectrum of water vapor, λλ 13924–14130 Å.

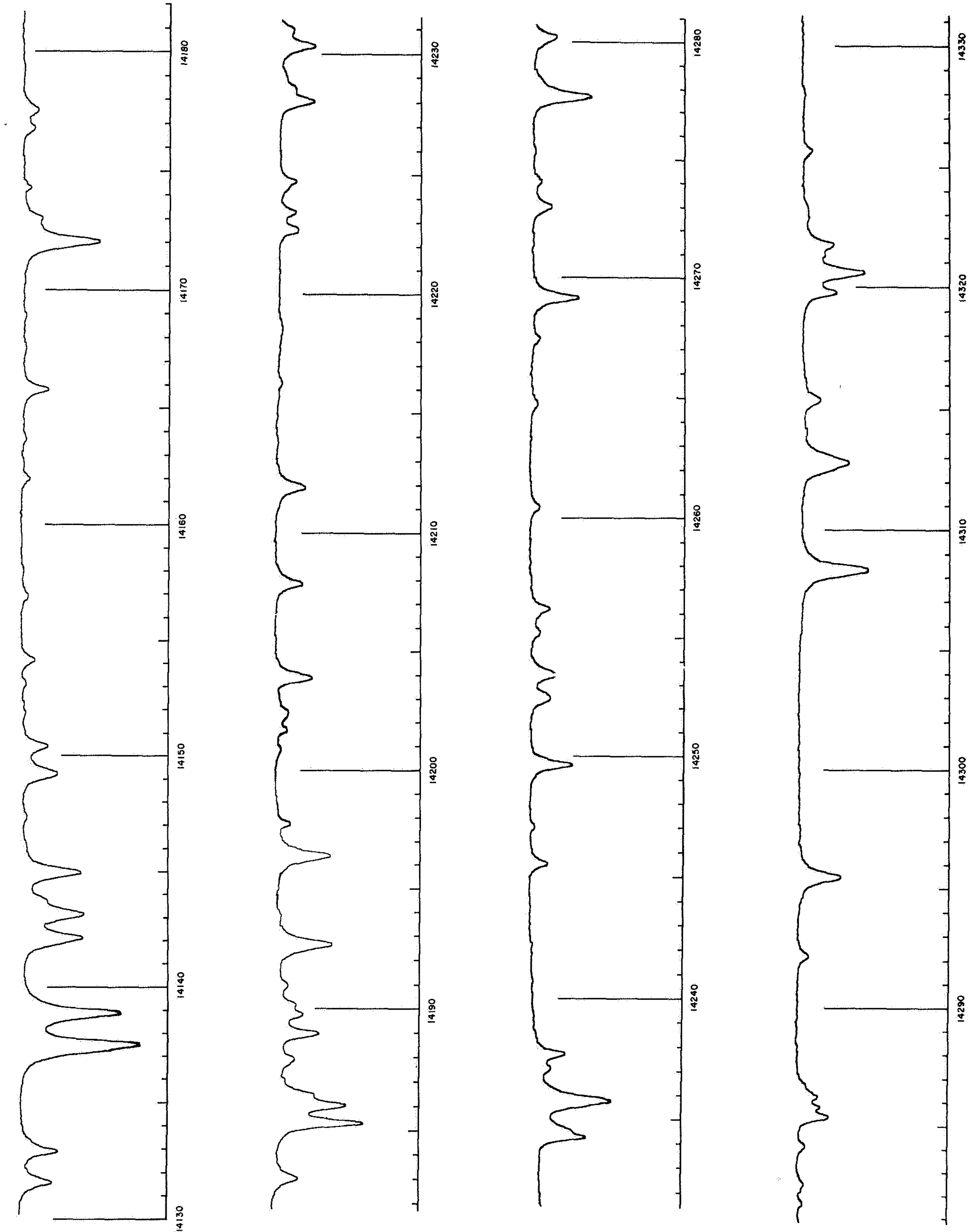

Fig. 5A Laboratory spectrum of water vapor, λλ 14130–14331 Å.

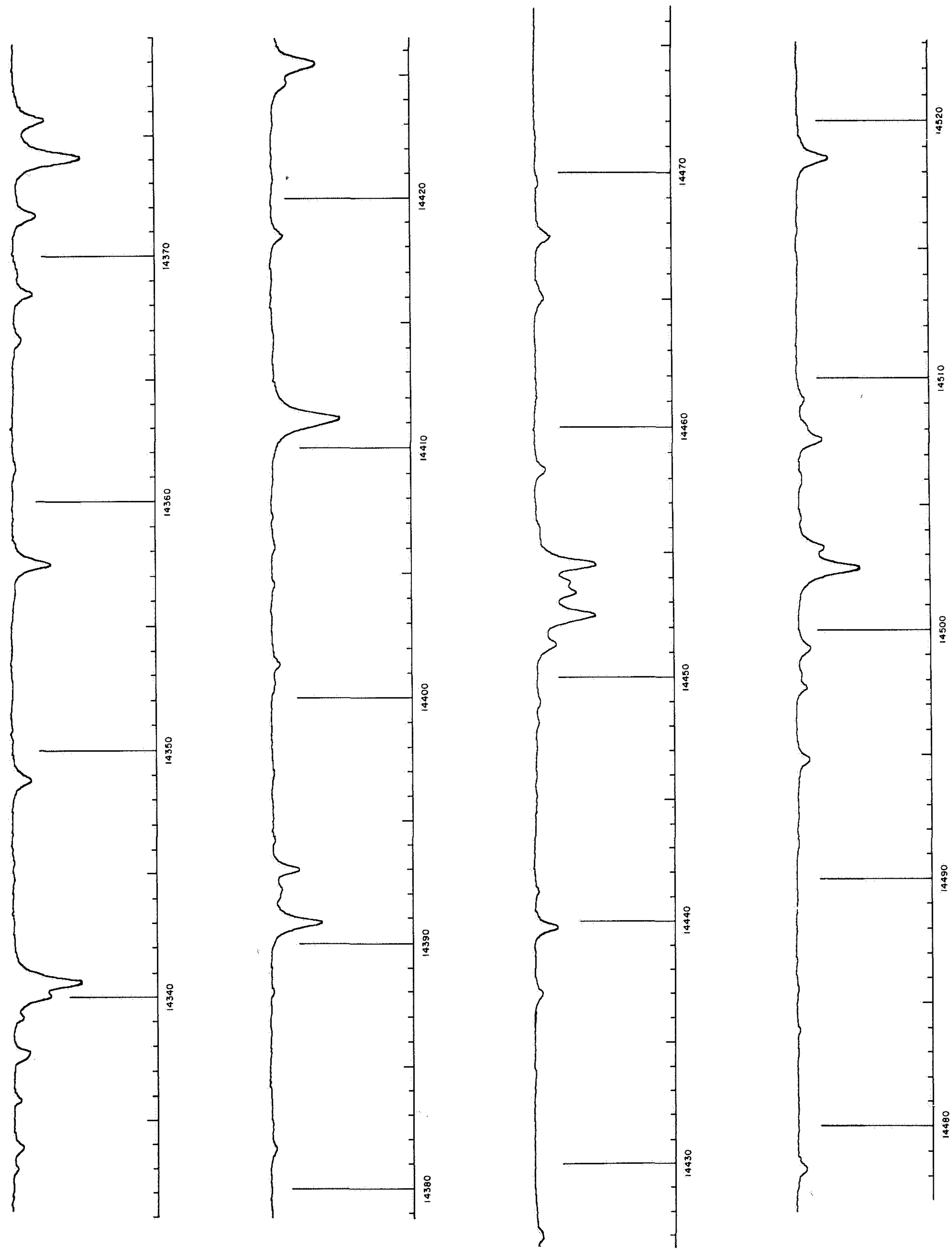

Fig. 6A Laboratory spectrum of water vapor, λλ 14331–14523 Å.

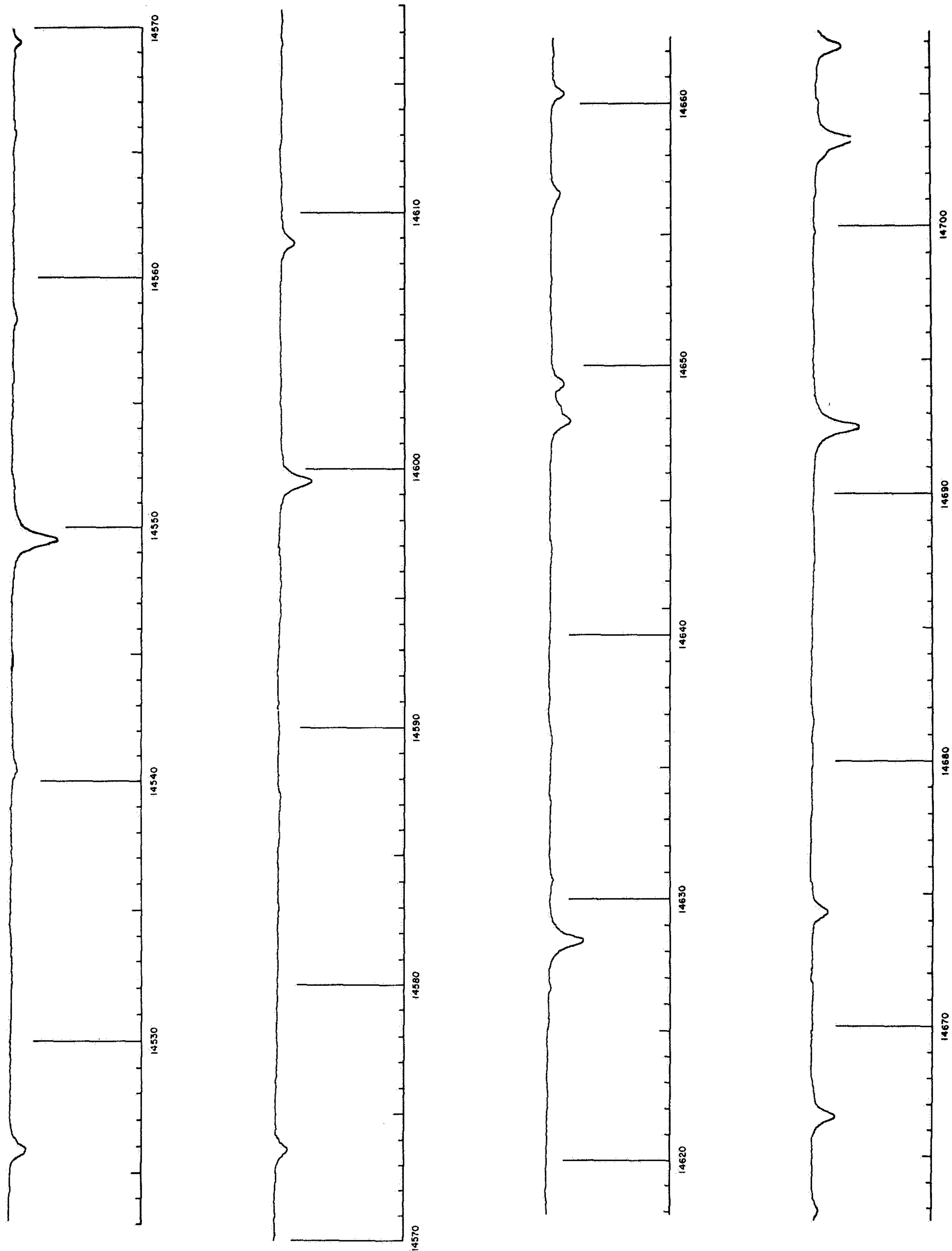

Fig. 7A Laboratory spectrum of water vapor, λλ 14523–14707 Å.

No. 161 ARIZONA-NASA ATLAS OF INFRARED SOLAR SPECTRUM, REPORT V

by L. A. BIJL, G. P. KUIPER, AND D. P. CRUIKSHANK

March 10, 1969

ABSTRACT

In this report Charts 23–32 of the *Atlas* are given, containing the solar spectrum $\lambda\lambda$12187–17731 Å, obtained from the NASA CV-990 Jet at an altitude of 39,000 ft with the LPL 4-meter spectrometer. A 600-lines/mm grating was used, blazed at 1.6 μ. The Michigan Atlas spectra and an LPL laboratory spectrum of the 2 ν_3 (1.6 μ) CH_4 band are included for comparison.

The Arizona-NASA Atlas will be divided into 4 parts:

Part I: Solar spectra, obtained with the 4-m spectrometer and a 1200-lines/mm grating. In preliminary form, Part I is published in *Comm. LPL* Nos. 123, 124, and 160; it extends from $\lambda\lambda$8487–14707, with two gaps, occasioned by the pressure of observing time, $\lambda\lambda$9725–10657 and $\lambda\lambda$12857–13138 Å; neither one contains heavy telluric absorptions.

Part II: Solar spectra, obtained with the 4-m spectrometer and a 600-lines/mm grating, *Comm. LPL* Nos. 161, 163, 164, and 166, together covering the interval $\lambda\lambda$12187–30900 Å, with some duplication and no gaps.

Part III: Solar spectra, obtained with the 4-m spectrometer and a 300-lines/mm grating. A preliminary report is given in *Comm. LPL* No. 125, for the region 3.1–3.3 μ; supplementary spectra to about 6 μ are to be obtained with the NASA-Ames Lear Jet and a new open-port spectrometer now nearly ready for test flights.

Part IV: Solar spectra, obtained with the LPL B-spectrometer and different gratings. First reports on this part of the Atlas will be given in *Comm. LPL Nos.* 162 and 165. The resolutions in Part IV are lower than those in the other Parts, by factors of 2–4, the same gratings having been used but the focal length of the B-spectrometer camera being only 0.95 m.

Supplementary ground-based solar and laboratory spectra will be added as needed.

This report gives the Charts 23–32 (λλ12187–17731), the first 10 charts of Part II of the Atlas. Relevant data on these are listed in Table 1. The interval λλ12187–14707 is reproduced on Charts 23–27 (Figs. 1–4) and overlaps Part I of the Atlas; it covers the gap that occurs on Chart 15 between strips *b* and *c*. The division of work among the authors is the same as in *Comm.* 160.

As before, corresponding parts of the Michigan *Photometric Atlas of the Near Infrared Solar Spectrum λ8465 – λ25242* are included for comparison.

The resolving power may be estimated from the pairs of lines at λλ15729, 16022, and 16157 Å, which are just clearly separated. The lines in each pair are, according to Mohler's *Table,* 0.3 cm^{-1} or about 0.8 Å apart. The resolving power therefore is 0.3 cm^{-1}, almost identical to the resolving power of the Michigan *Atlas,* as may be verified by comparing pairs of solar lines in both sets of records.

A laboratory spectrum of the 2 ν_3 methane band at 1.6 μ is included in Fig. A. A 10-cm absorption cell with p = 9 cm methane was placed in the light-beam, thus corresponding to an amount of methane of 12 mm atm. The spectrum was used in estimating the relative intensities of the methane lines in the solar spectrum.

As before, available identifications of the stronger solar lines are included in the solar records. All observed absorption lines are marked with a numbered dot below the spectral trace; above this trace, a dot indicates absorption by H_2O, a vertical line by CO_2, and a triangle by CH_4.

Acknowledgments. We again wish to thank Messrs. J. Percy, B. McClendon, A. Thomson, and Rev. G. Sill of LPL and Mr. D. Olsen of NASA-Ames for their assistance during the flights. Mrs. A. Agnieray and Mr. S. M. Larson assisted in the preparation of the figures. This research was supported by NASA through Grant NsG 161-61 and the University of Arizona Institutional Grant NGR 03-002-09.

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Mohler, O. C. 1955, *A Table of Solar Spectrum Wavelengths 11984 A to 25578 A,* Ann Arbor.

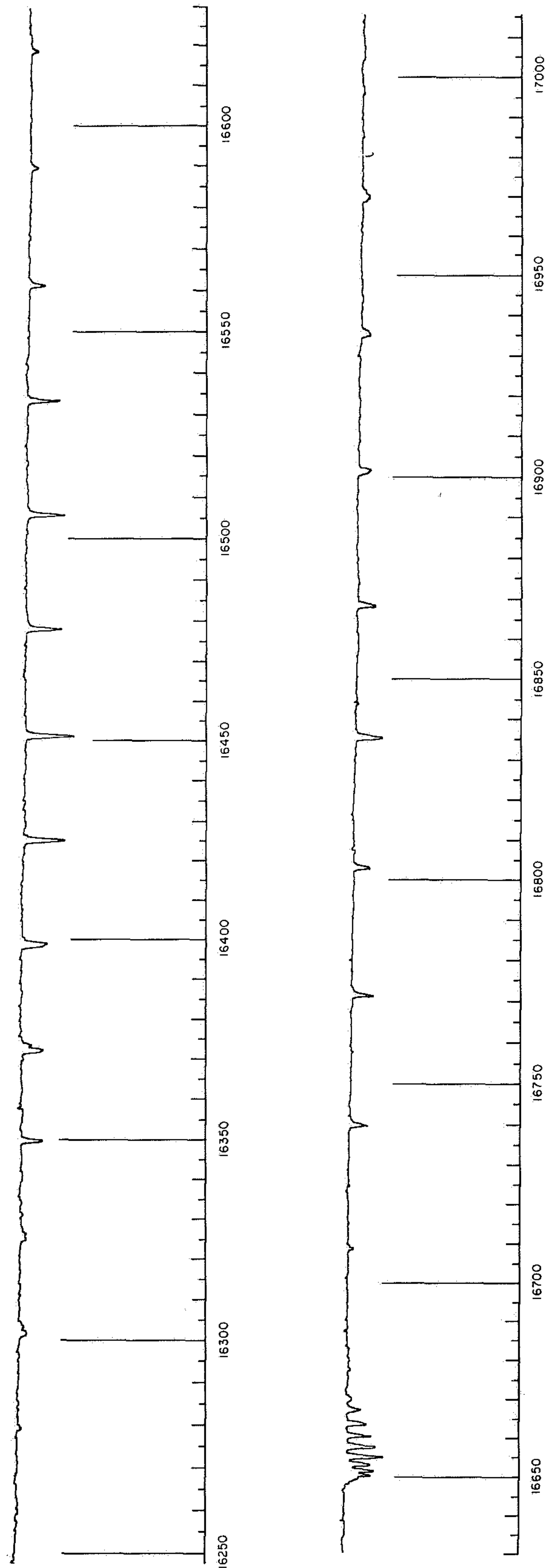

Fig. A Laboratory spectrum of 2 ν_3 methane band. (Scale different from solar spectrum scale.)

TABLE 1

SOLAR SPECTRUM RECORDS, 4-M SPECTROMETER, NASA CV-990 JET
1.6 μ GRATING (600 LINES/MM), SLIT AND CELL 0.10 MM, PBS CELL (—70°C), τ = 0.12 SEC, 1 μ FILTER

FIG.	CHART	λ(Å)	1968 DATE	UT	ALT. (FT)	OUTSIDE TEMP. (°C)	CABIN ALT. (FT)	GAIN
1.	23 a	12187–12239	July 17	18:15; 18:20	39,000	—49°C	8500	4–6
	b	12239–12414	July 17	18:17	39,000	—49	8500	4–6
	c	12239–12414	July 17	18:22	39,000	—49	8500	4–6
	d	12414–12584	July 17	18:25	39,000	—49	8500	4–6
2.	24 a	12584–12762	July 17	18:28	39,000	—49	8500	4–6
	b	12762–12943	July 17	18:32	39,000	—49	8500	4–6
	c	12943–13120	July 17	18:35	39,000	—49	8500	4–6
	d	13120–13299	July 17	18:39	39,000	—49	8500	4–6
3.	25 a	13299–13476	July 17	18:42	39,000	—49	8500	4–6
	b	13476–13654	July 17	18:45	39,000	—49	8500	4–6
	c	13654–13829	July 17	18:48	39,000	—49	8500	4–6
	d	13829–14006	July 17	18:52	39,000	—49	8500	4–6
4.	26 a	14006–14182	July 17	18:55	39,000	—50	8500	4–6
	b	14182–14357	July 17	18:58	39,000	—50	8500	4–6
	c	14357–14534	July 17	19:02	39,000	—50	8500	4–6
	d	14534–14708	July 17	19:06	39,000	—50	8500	4–6
5.	27 a	14708–14868	July 17	19:09	39,000	—50	8500	4–6
	b	14868–15032	July 17	19:12	39,000	—50	8500	4–6
	c	15032–15195	July 17	19:16	39,000	—50	8500	4–6
	d	15195–15355	July 17	19:19	39,000	—50	8500	4–6
6.	28 a	15355–15513	July 17	19:22	39,000	—50	8500	4–6
	b	15513–15672	July 17	19:25	39,000	—50	8500	4–6
	c	15672–15825	July 17	19:27	39,000	—50	8500	4–6
	d	15825–15885	July 17	19:29	39,000	—50	8500	4–6
		15825–15885	July 17	19:36	39,000	—50	8500	4–6
7.	29 a	15885–16060	July 17	19:31; 19:35	39,000	—51	8500	4–6
	b	15885–16058	July 17	19:39	39,000	—51	8500	4–6
	c	16058–16230	July 17	19:42	39,000	—51	8500	4–6
	d	16230–16400	July 17	19:46	39,000	—51	8500	4–6
8.	30 a	16400–16571	July 17	19:49	39,000	—51	8500	4–6
	b	16571–16739	July 17	19:53	39,000	—51	8500	4–6
	c	16739–16852	July 17	19:56	39,000	—51	8500	4–6
	d	16739–16854	July 17	19:58	39,000	—51	8500	4–6
9.	31 a	16854–17010	July 17	20:00	39,000	—52	8500	4–6
	b	17010–17168	July 17	20:03	39,000	—52	8500	4–6
	c	17168–17318	July 17	20:06	39,000	—52	8500	4–6
	d	17318–17398	July 17	20:08	39,000	—52	8500	5–2
		*17325–17398	July 19	20:21	39,000	—53	8500	5–3
10.	32 a	17398–17564	July 17	20:11	39,000	—52	8500	5–2
	b	*17398–17564	July 19	20:24	39,000	—53	8500	5–3
	c	17564–17731	July 17	20:14	39,000	—52	8500	5–2
	d	*17564–17731	July 19	20:27	39,000	—53	8500	5–3

*Slit = 0.08 mm

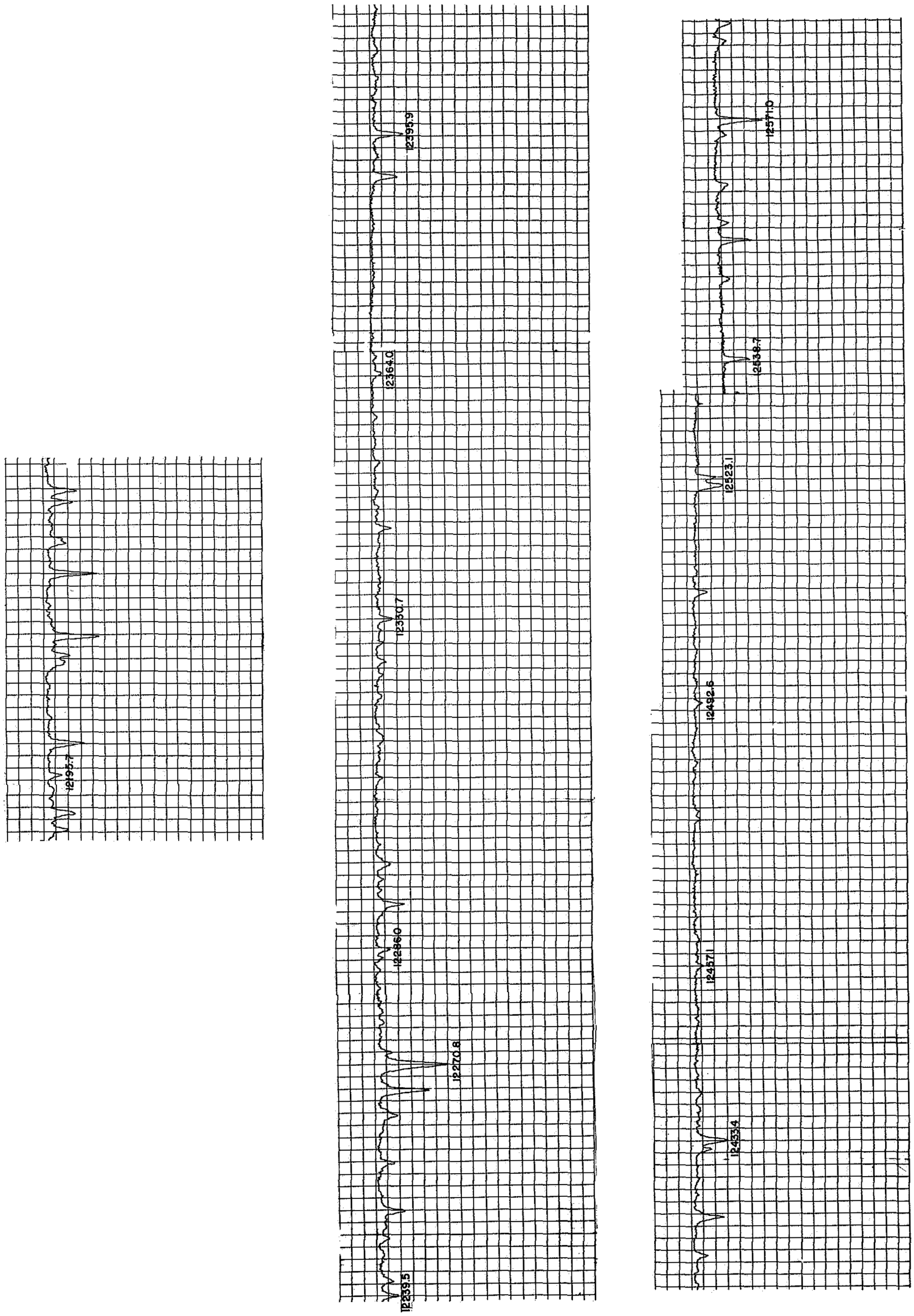

Fig. 1M Part of Michigan Atlas that matches Fig. 1 (1M–10M reproduced with permission.)

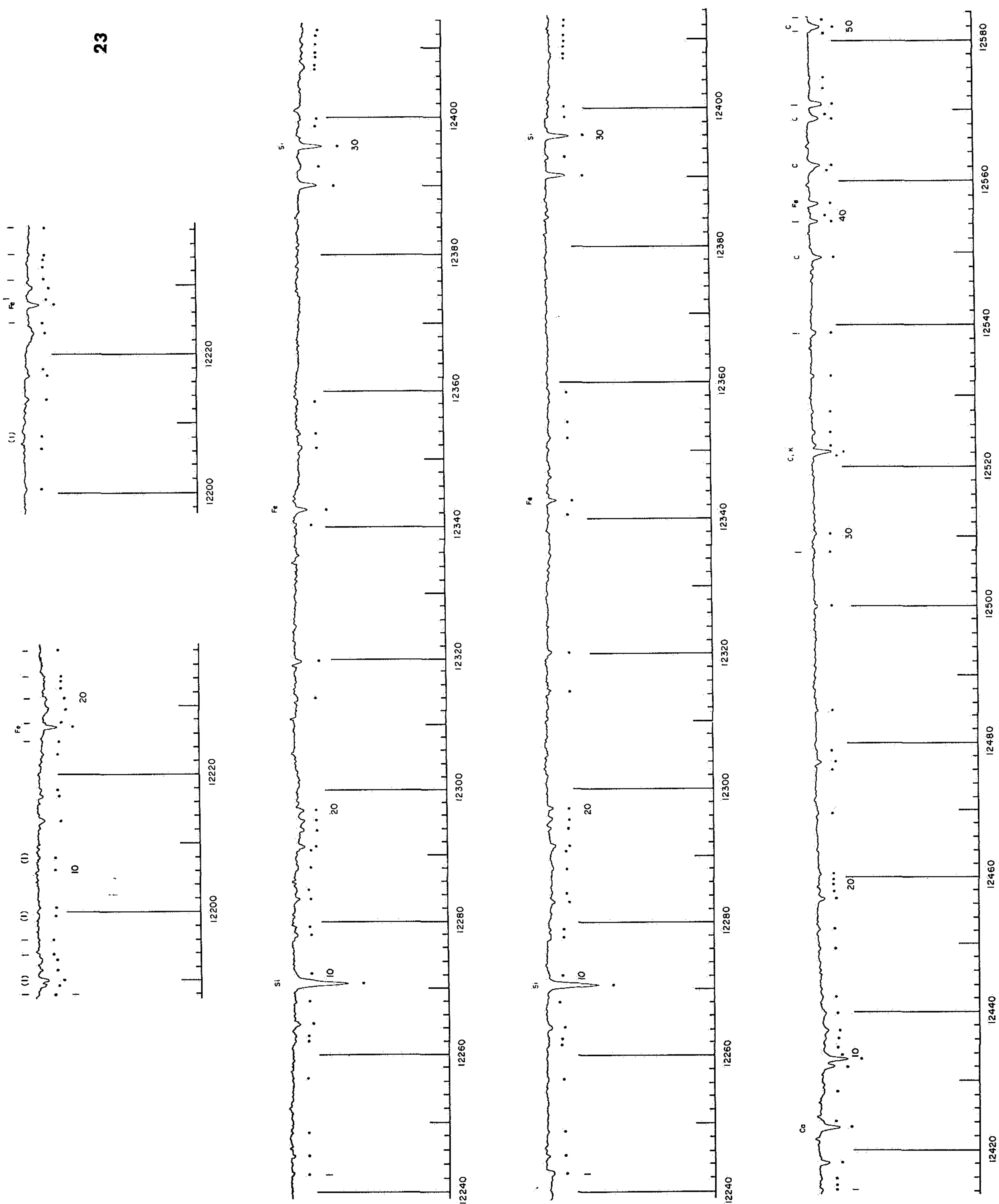

Fig. 1 Solar Spectrum λλ12187–12584 Å, in four strips (cf. Table 1).

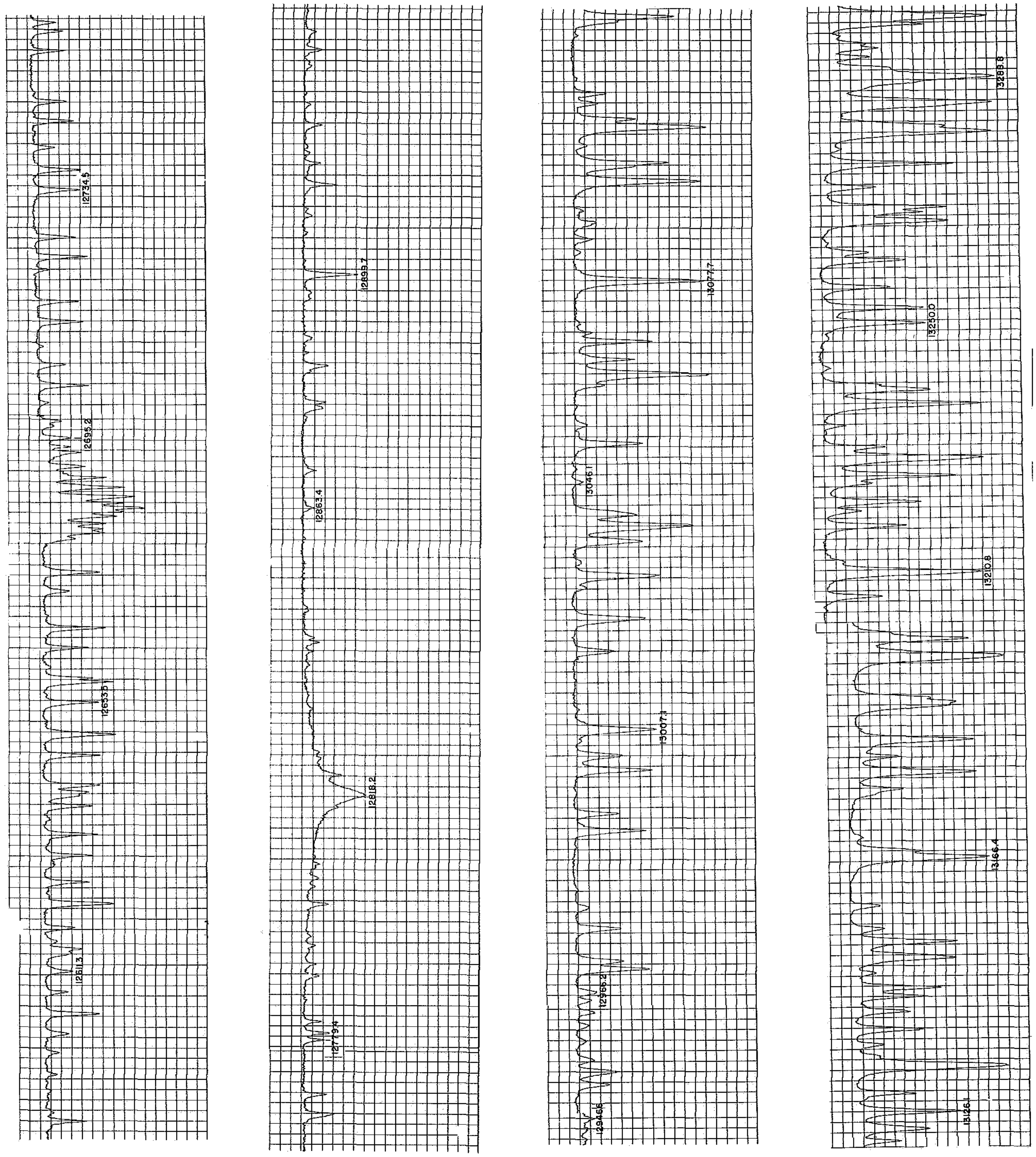

Fig. 2M Part of Michigan Atlas that matches Fig. 2.

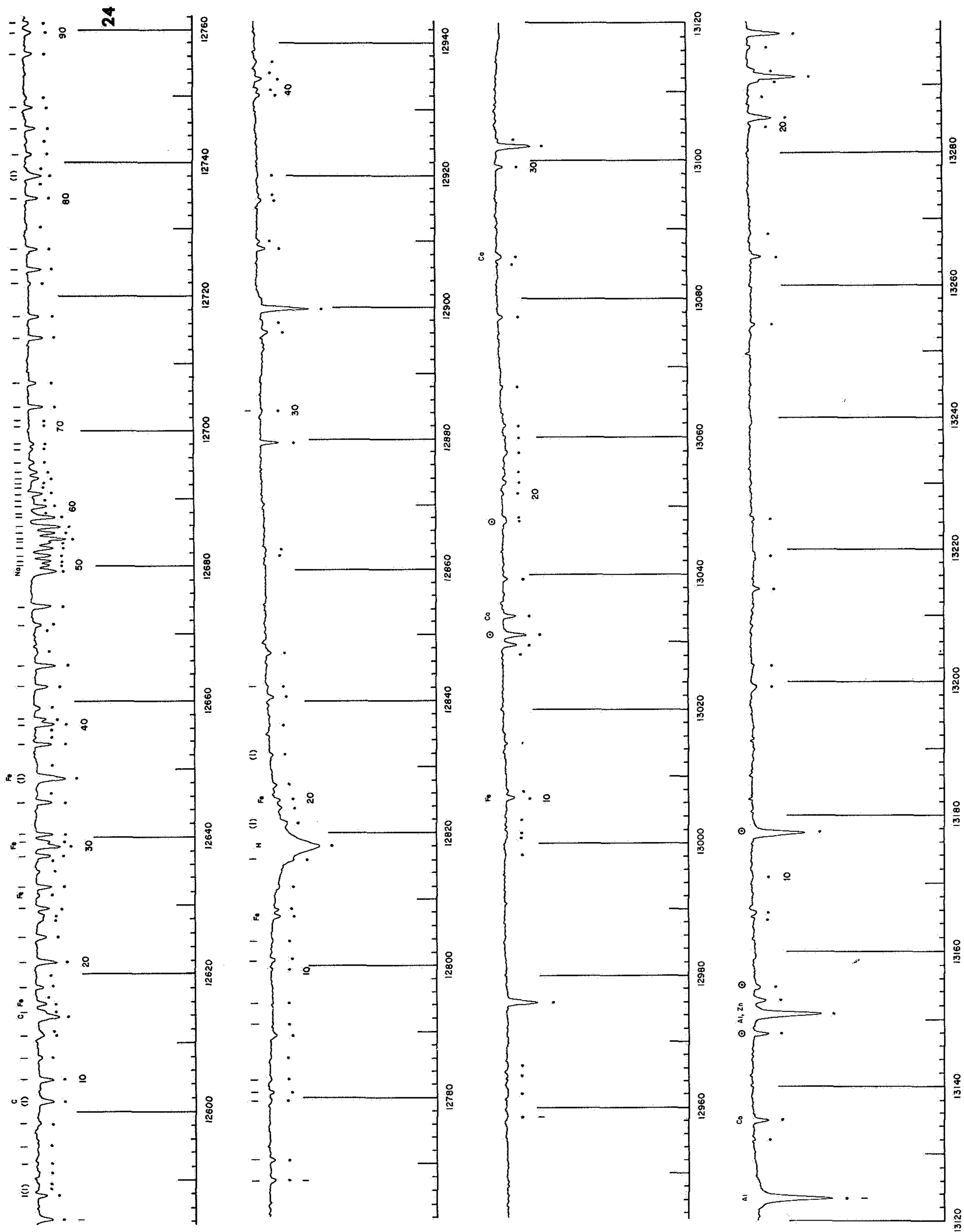

Fig. 2 Solar Spectrum λλ12584–13299 Å, in four strips (cf. Table 1).

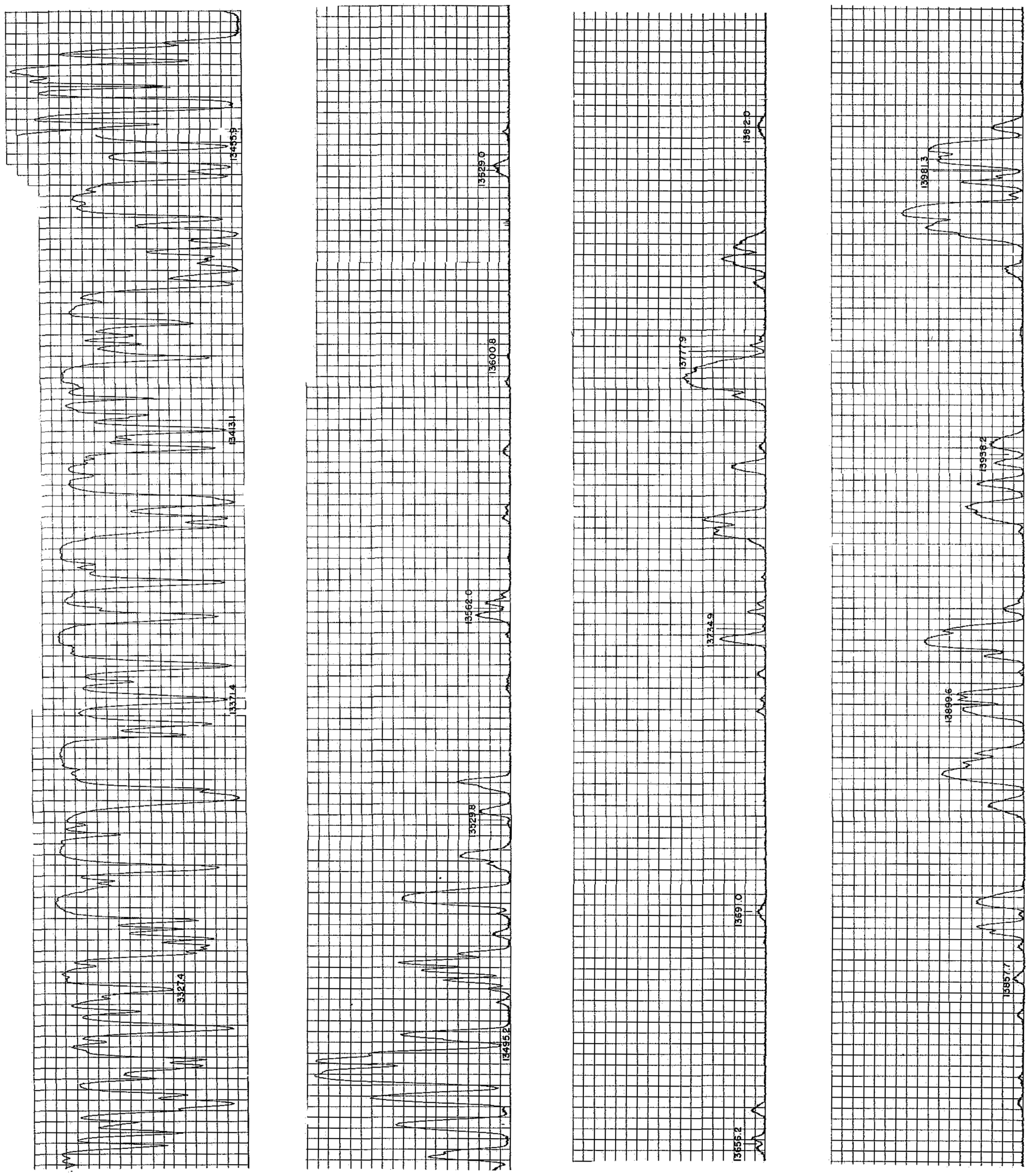

Fig. 3M Part of Michigan Atlas that matches Fig. 3.

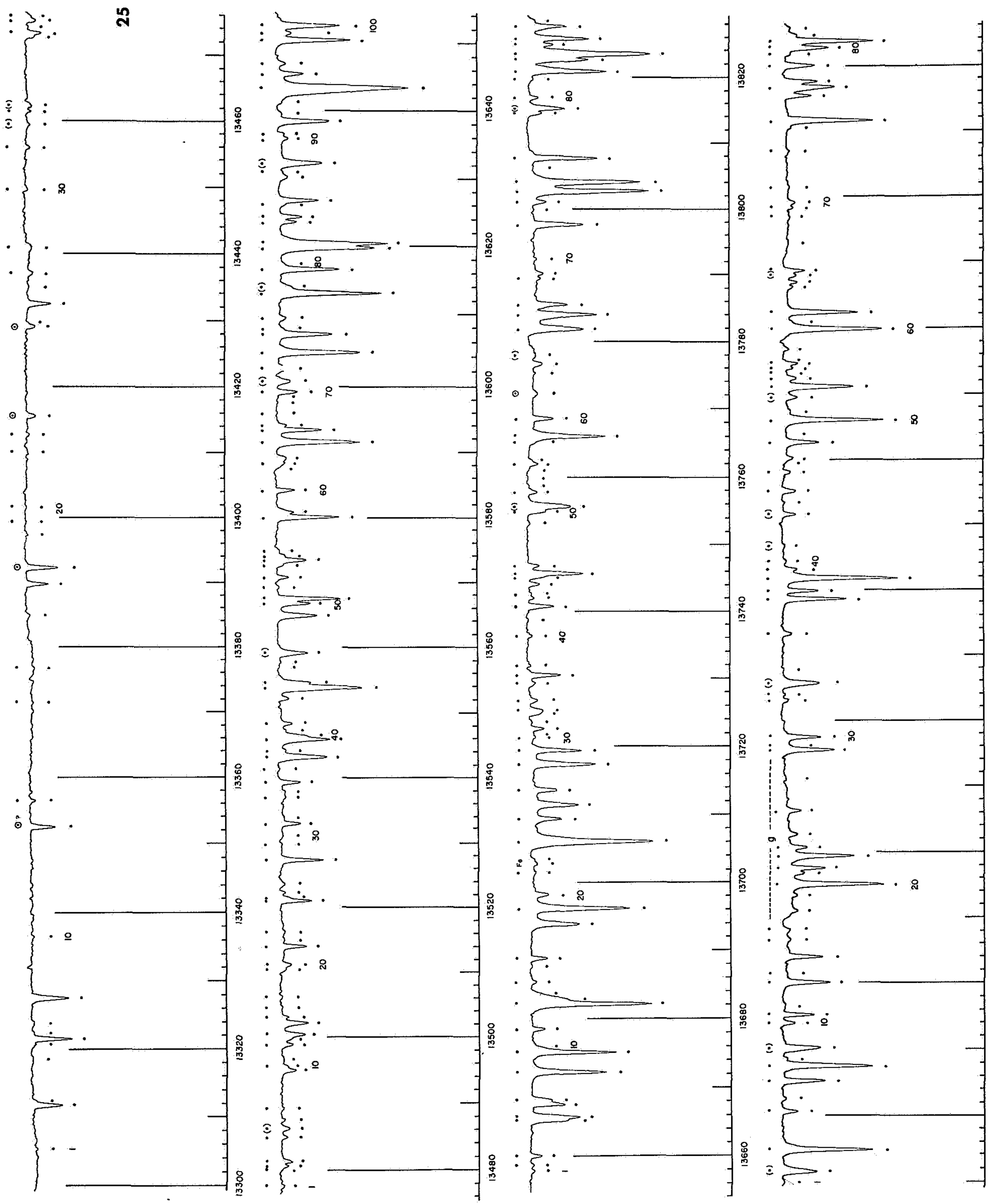

Fig. 3 Solar Spectrum λλ13299–14006 Å, in four strips (cf. Table 1).

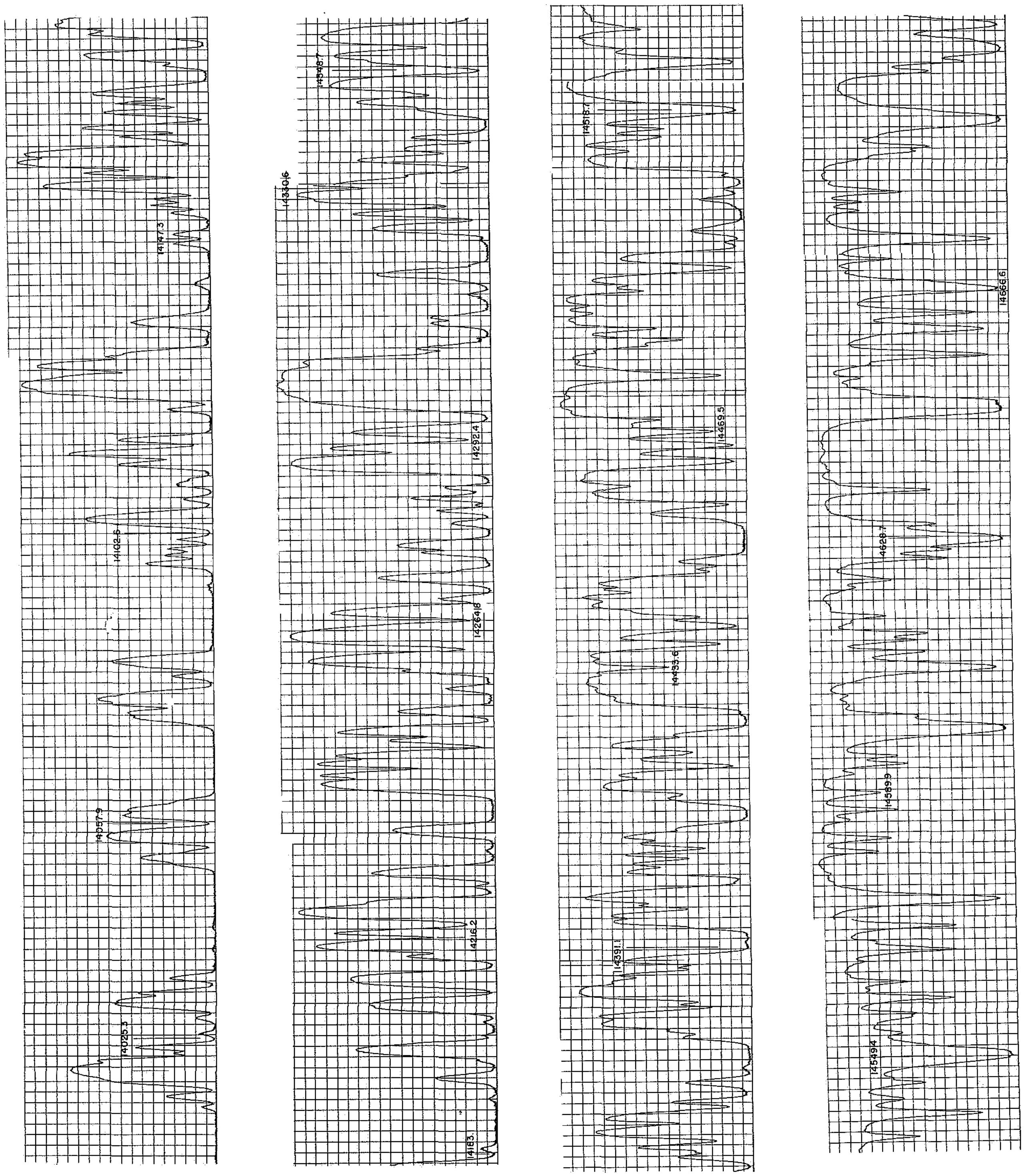

Fig. 4M Part of Michigan Atlas that matches Fig. 4.

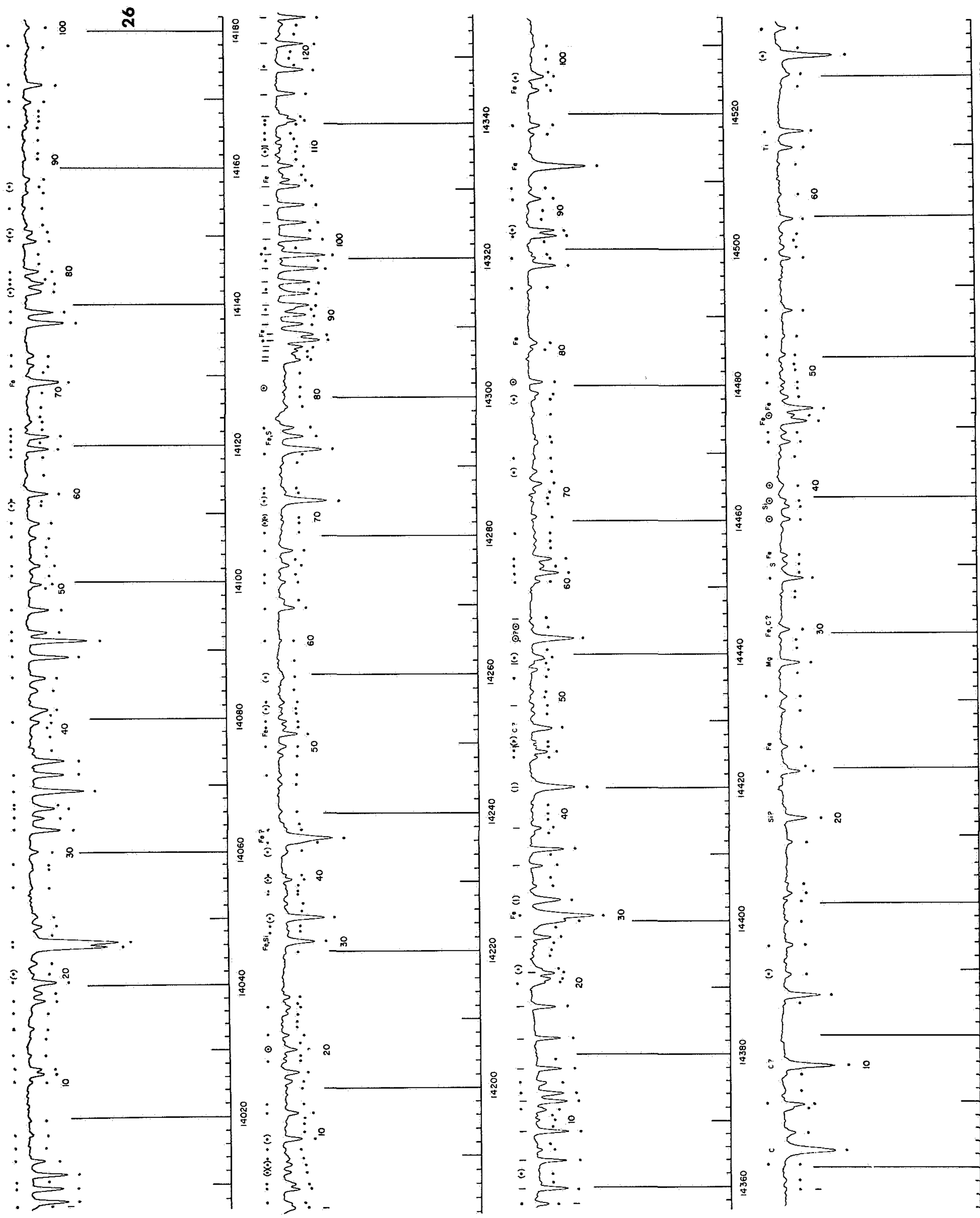

Fig. 4 Solar Spectrum λλ14006–14708 Å, in four strips (cf. Table 1).

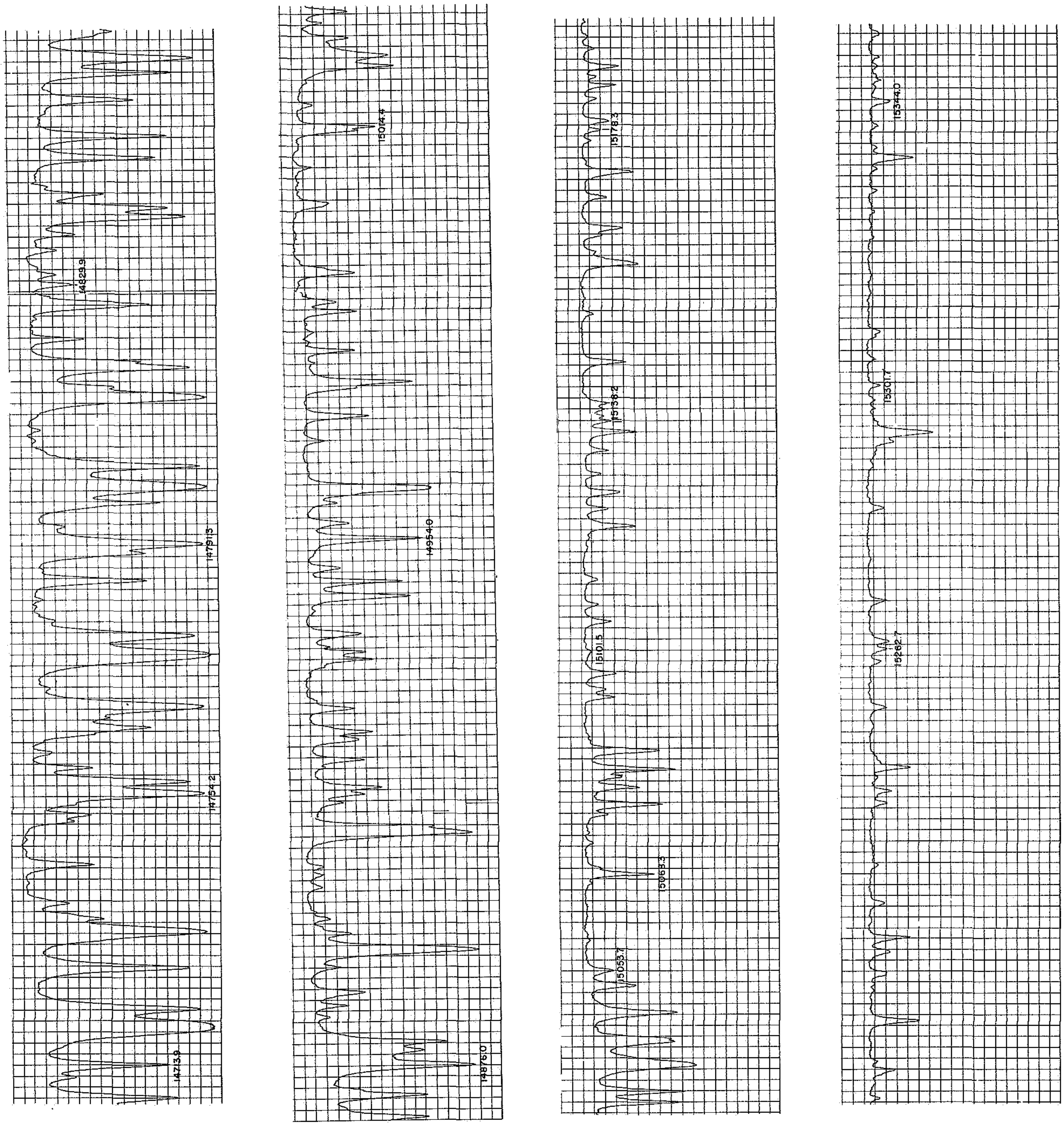

Fig. 5M Part of Michigan Atlas that matches Fig. 5.

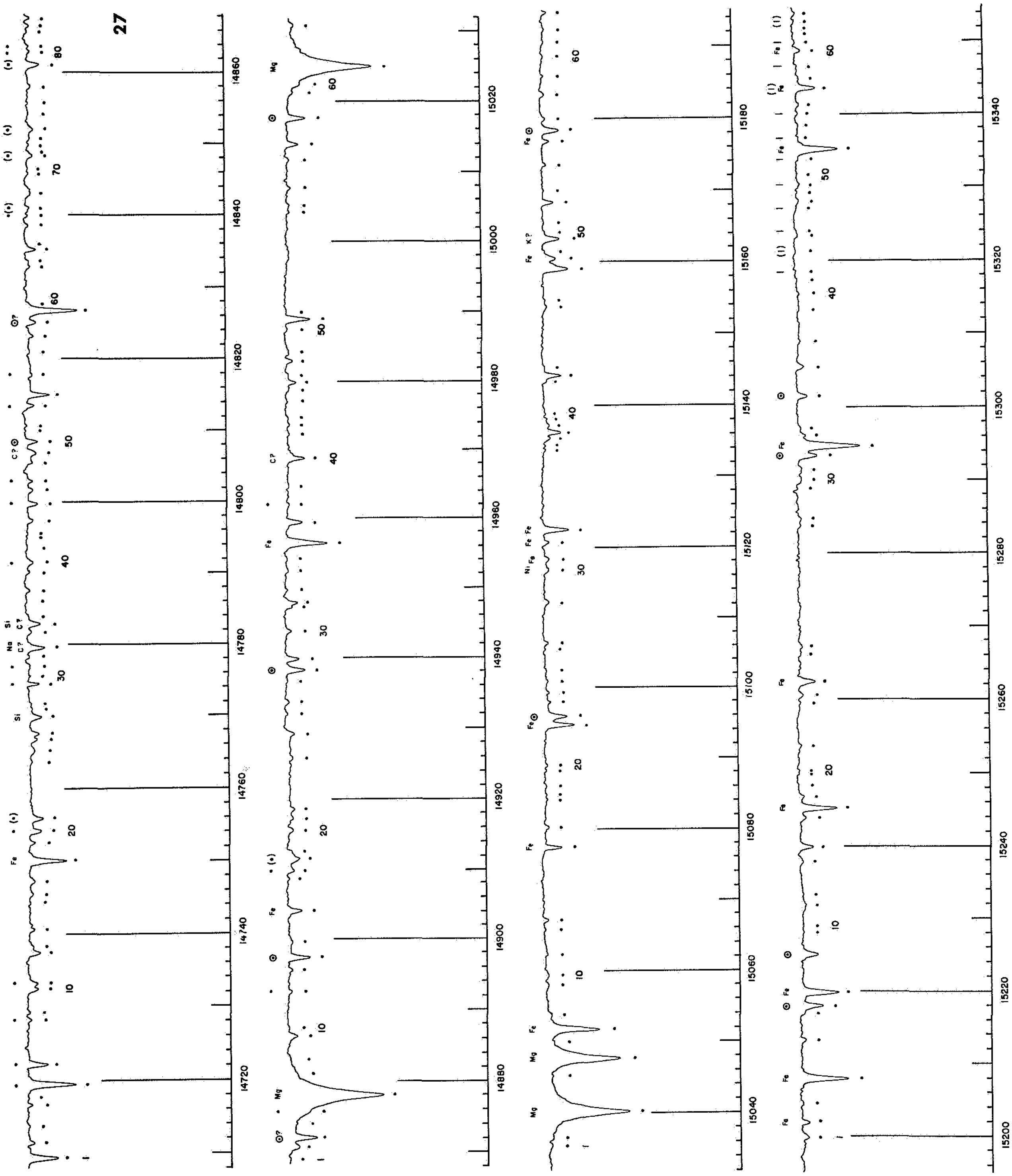

Fig. 5 Solar Spectrum λλ14708–15355 Å, in four strips (cf. Table 1).

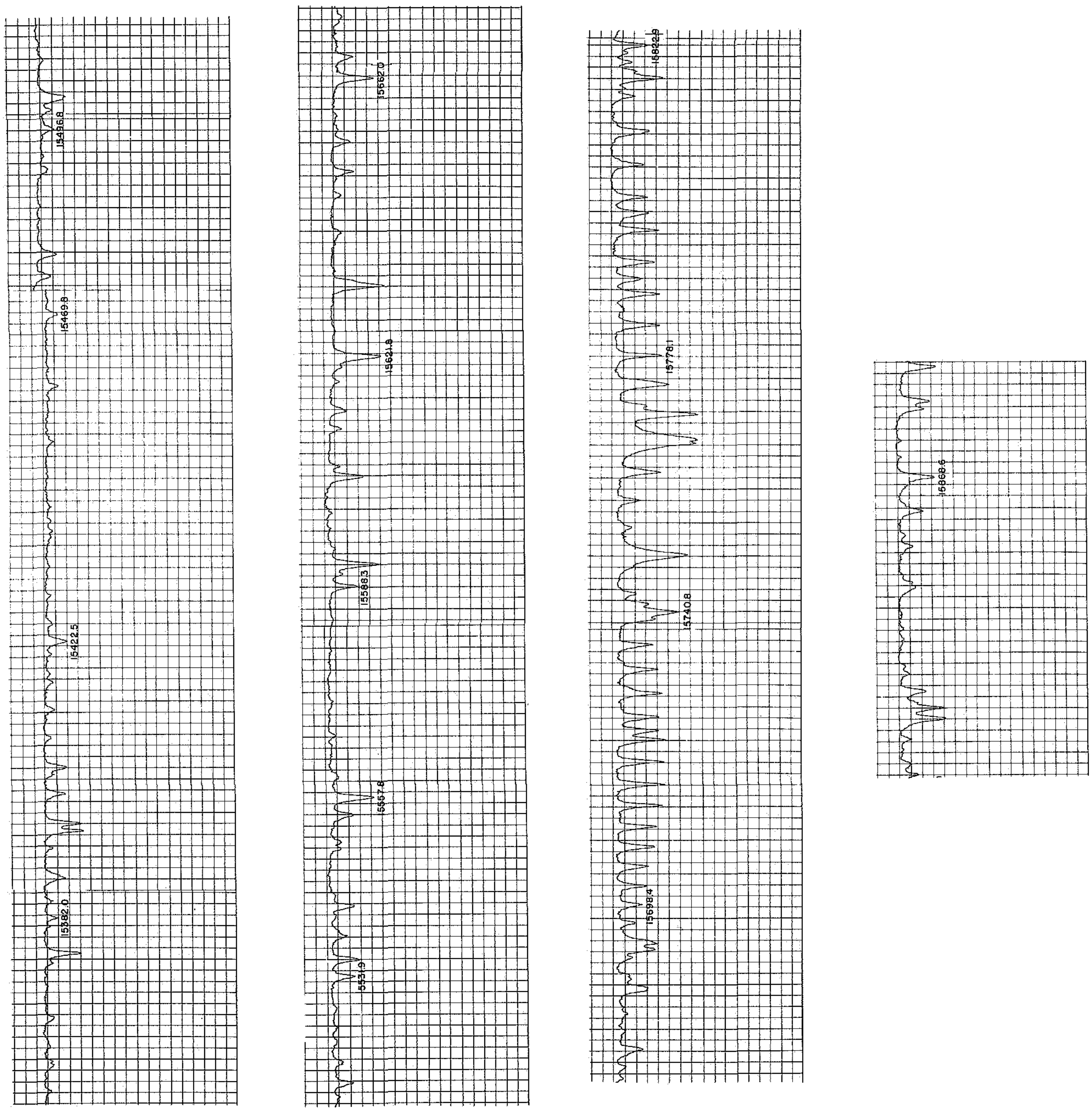

Fig. 6M Part of Michigan Atlas that matches Fig. 6.

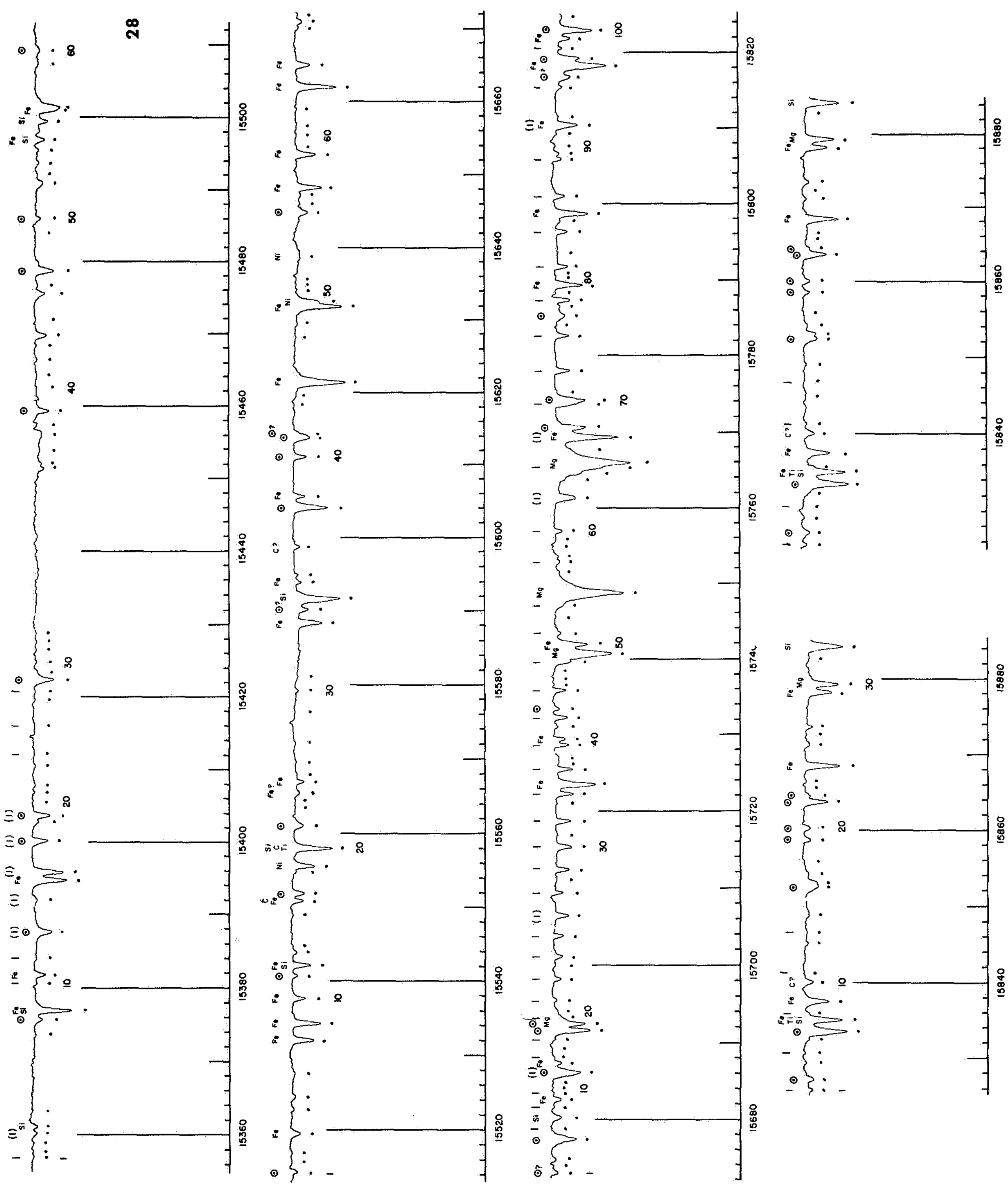

Fig. 6 Solar Spectrum λλ15355–15885 Å, in four strips (cf. Table 1).

Fig. 7M Part of Michigan Atlas that matches Fig. 7.

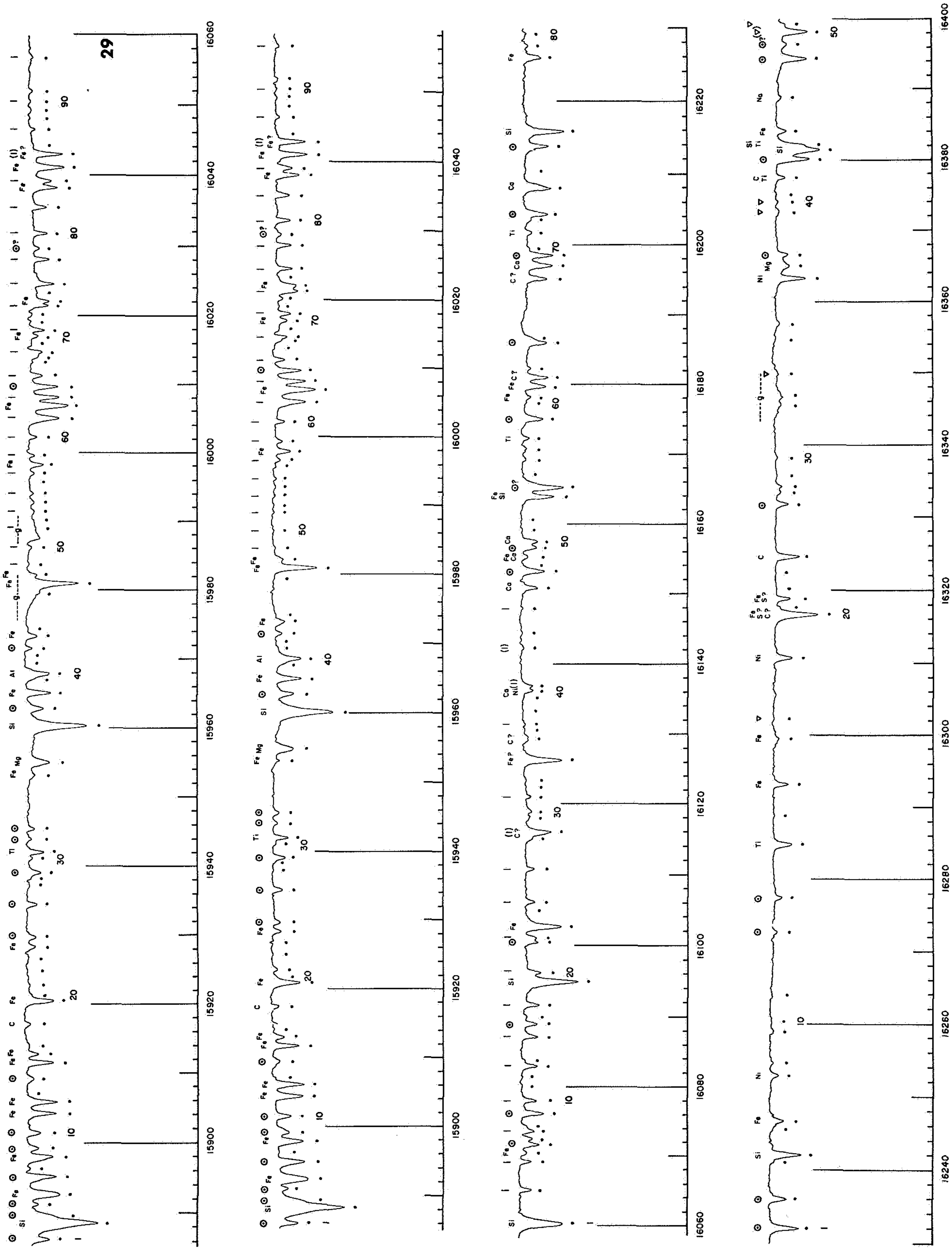

Fig. 7 Solar Spectrum λλ15885–16400 Å, in four strips (cf. Table 1).

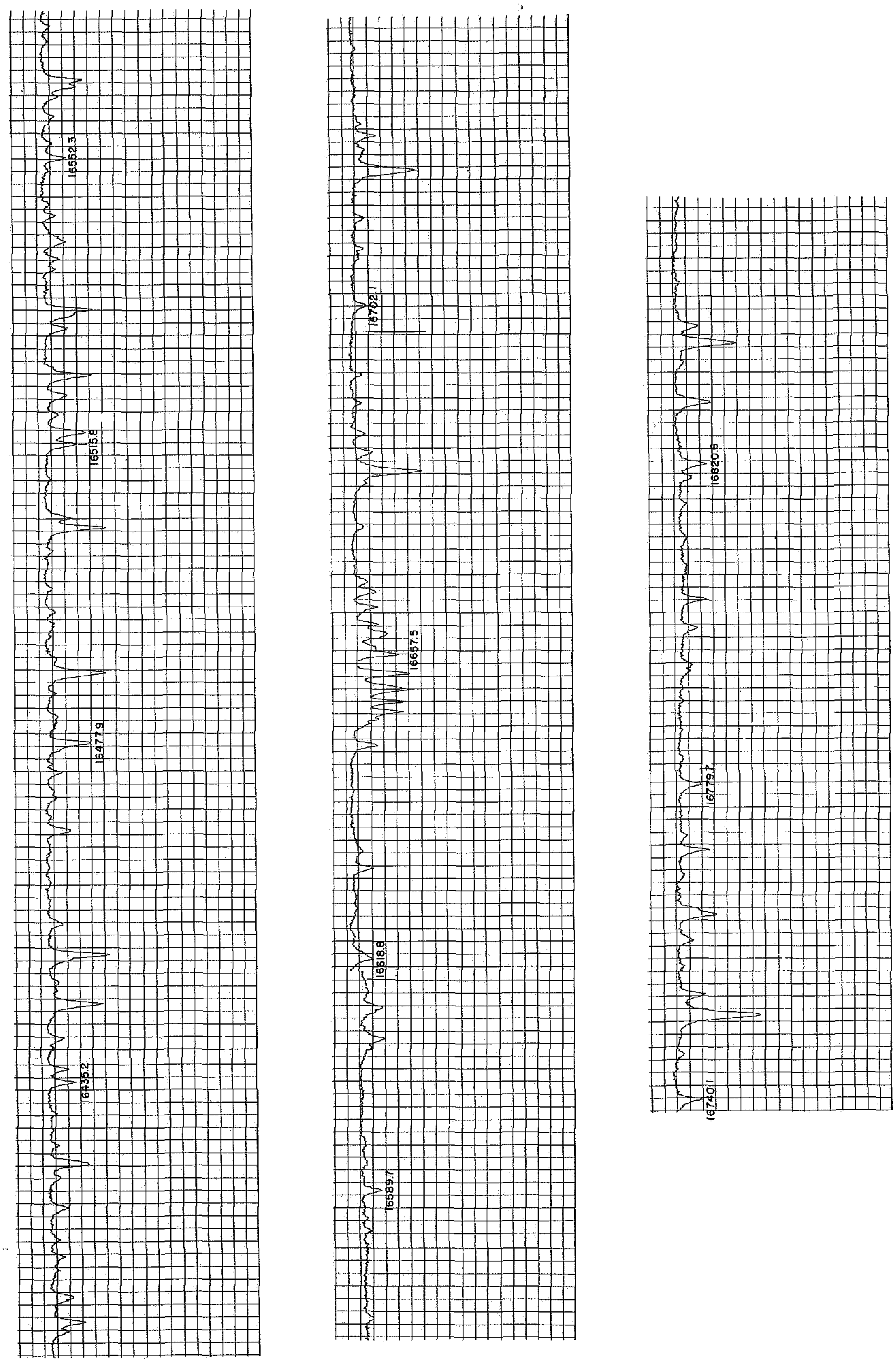

Fig. 8M Part of Michigan Atlas that matches Fig. 8.

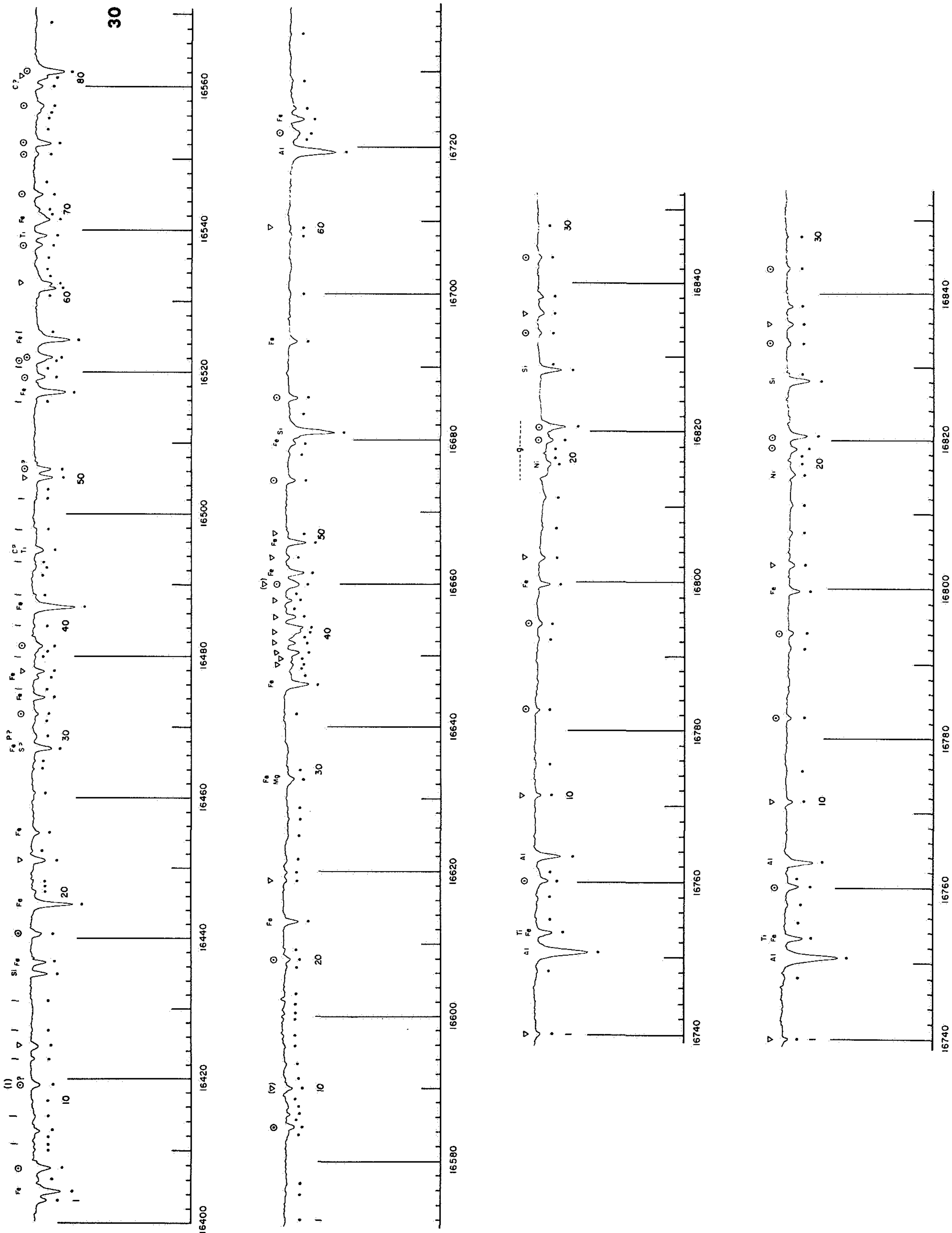

Fig. 8 Solar Spectrum λλ16400–16854 Å, in four strips (cf. Table 1).

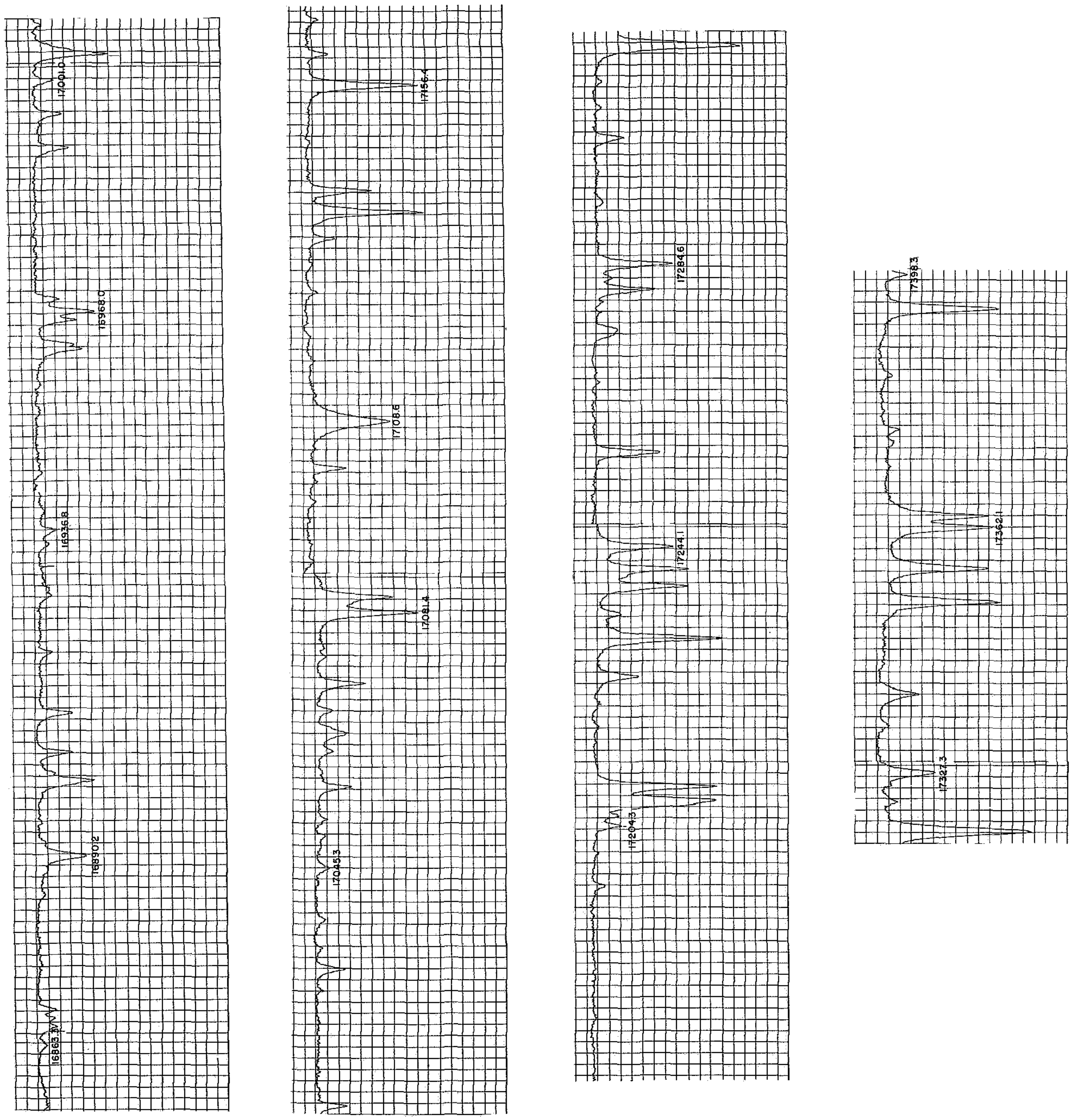

Fig. 9M Part of Michigan Atlas that matches Fig. 9.

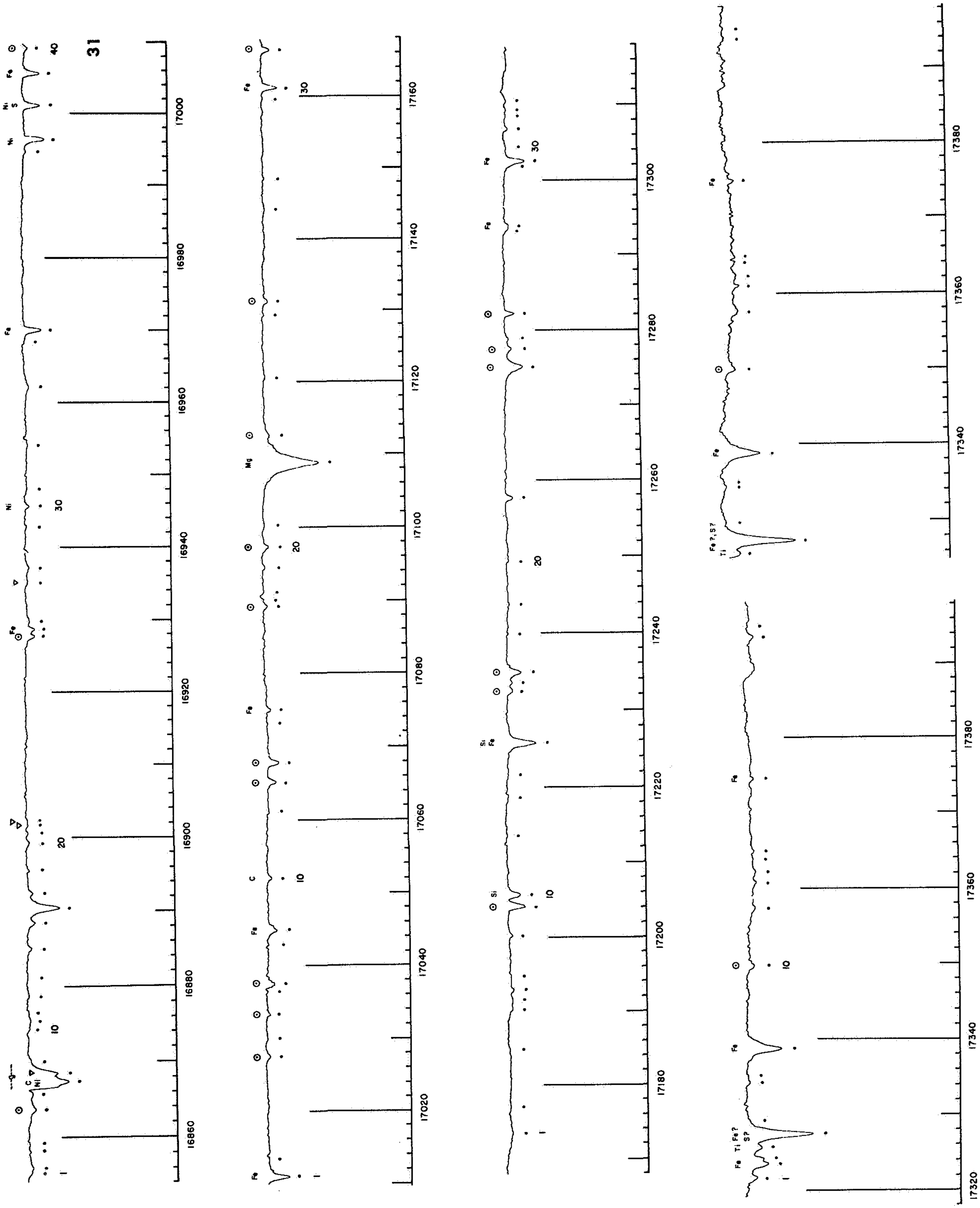

Fig. 9 Solar Spectrum λλ16854–17398 Å, in four strips (cf. Table 1).

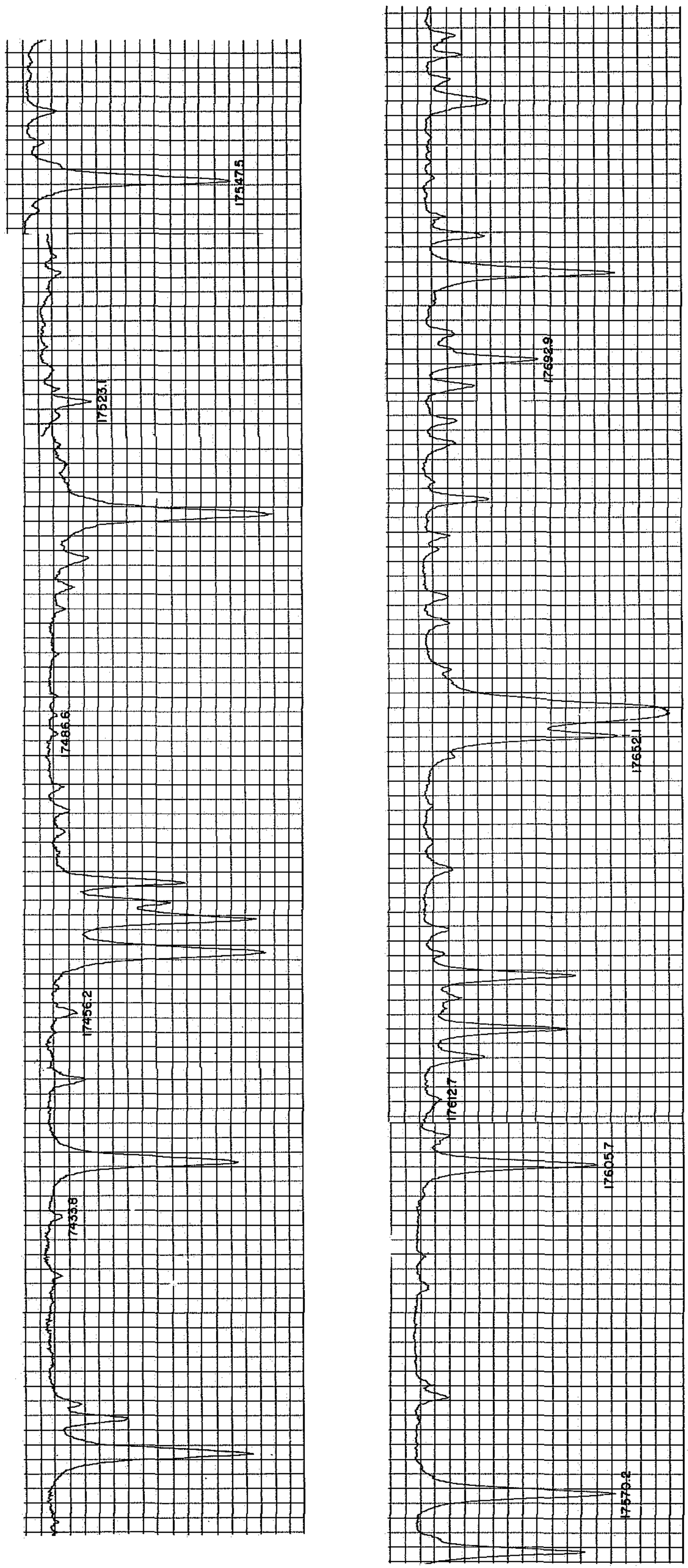

Fig. 10M Part of Michigan Atlas that matches Fig. 10.

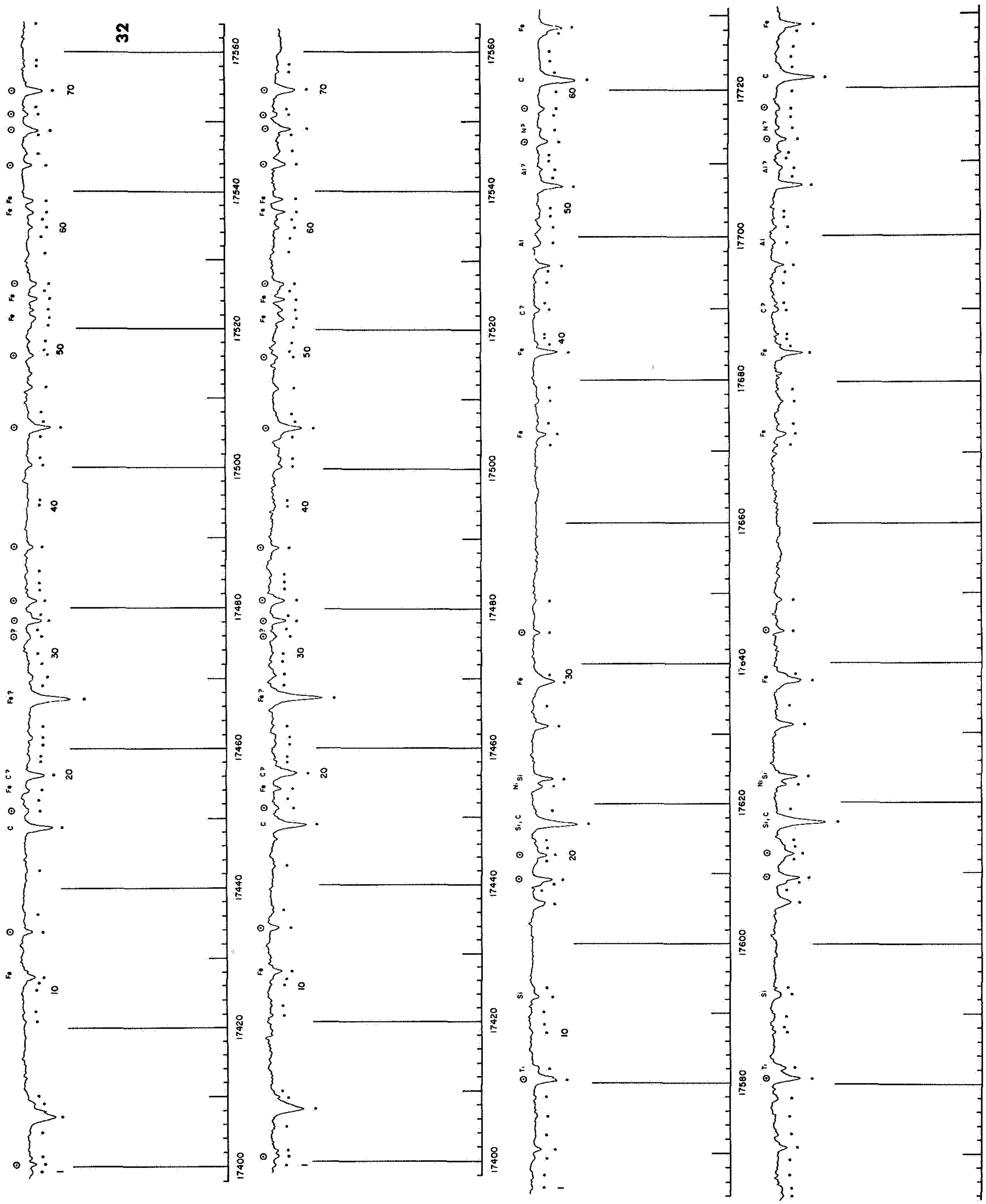

Fig. 10 Solar Spectrum λλ17398–17731 Å, in four strips (cf. Table 1).

No. 162 ARIZONA-NASA ATLAS OF INFRARED SOLAR SPECTRUM, REPORT VI

by G. P. KUIPER, A. B. THOMSON, L. A. BIJL, AND D. C. BENNER

May 12, 1969

ABSTRACT

In this paper we reproduce the solar spectrum as recorded with the LPL B-Spectrometer on the NASA CV-990, using the 1-μ grating (1200 lines/mm). The resolution is about 4 times lower than in the corresponding records obtained with the LPL 4-m spectrometer.

During the July-August 1968 flights of the NASA CV-990 Jet two LPL spectrometers were recording the solar spectrum: the 4-m spectrometer (*Comm. LPL* No. 126), of which records have been published in *Comm. LPL* Nos. 123, 124, 125, 160, and 161; and the B-spectrometer (a scaled-up version of the A-spectrometer, *Comm. LPL* No. 16, of about 1.5 × larger dimensions). Part of the B-spectrometer records are published herewith.

The same type of auxiliary equipment (gratings, detectors, electronics) and cell widths, were used here as with the 4-m spectrometer. With the on-board vibration problems having essentially been solved, the lower resolving power of the B-spectrometer is found to be just in proportion to the shorter focal lengths of its camera mirror, 0.95 m vs. 3.92 m, a ratio of 4.1. The resolution in the spectra here reproduced is indeed 4 times lower than that in the corresponding 4-m spectra, *Comm. LPL* Nos. 123, 124, and 160.

The wavelength scale and classification of absorption lines are adapted from the 4-m spectra, whose scale in turn was based on Babcock-Moore's *The Solar Spectrum* $\lambda6600$–$\lambda13495$ and Mohler's *Table of Solar Spectrum Wavelengths 11984A–25578A*. The symbols in the spectra have the same meaning as before: a numbered dot *below* the spectral trace to be used for later reference; a dot *above* the trace for a water-vapor absorption; and vertical lines for O_2 and CO_2 absorptions. The observational data on Figs. 1–9 are listed in Table 1.

The continuum is sometimes distorted by minor interference fringes of the filter used, or else by guiding errors, which this time we have not indicated since for each spectral interval we were able to give independent traces.

Acknowledgments. We wish to record our indebtedness to NASA Hq. and NASA-Ames for their support of this program; to Messrs. J. Percy and B. McClendon for assistance with the electronics during the flights; to Mrs. A. Agnieray for her assistance in the preparation of the spectral charts for publication. The program was supported by NASA through Grants NsG 161-61 and NGR-03-002-091.

TABLE 1

SOLAR SPECTRUM RECORDS, LPL B-SPECTROMETER, NASA CV 990 JET
1 μ GRATING (1200 L/MM), SLIT AND CELL 0.10 MM, $\tau = 0.12$, 1 μ FILTER

FIG.	CHART	λ(Å)	1968 DATE	UT	ALT. (FT.)	OUTSIDE TEMP. (°C)	ALT. (FT.) CABIN	GAIN
1.	B1 a	8205– 8616	July 18	18:52	39,000	−56	8500	4–2
	b	8199– 8616	July 18	18:26	39,000	−56	8500	4–2
	c	8616– 9025	July 18	18:56	39,000	−56	8500	4–2
	d	8616– 9025	July 18	18:29	39,000	−56	8500	4–2
2.	B2 a	9025– 9424	July 18	18:59	39,000	−56	8500	4–2
	b	9025– 9424	July 18	18:33	39,000	−56	8500	4–2
	c	9424– 9815	July 18	19:02	39,000	−56	8500	4–2
	d	9424– 9815	July 18	18:37	39,000	−56	8500	4–2
3.	B3 a	9815–10192	July 18	19:05	39,000	−56	8500	4–2
	b	9815–10192	July 18	18:40	39,000	−56	8500	4–2
	c	10192–10565	July 18	19:09	39,000	−56	8500	4–2
	d	10192–10565	July 18	18:43	39,000	−56	8500	4–2
4.	B4 a	10565–10925	July 18	19:30	39,000	−56	8500	4–2
	b	10565–10925	July 18	19:12	39,000	−56	8500	4–2
	c	10925–11275	July 18	19:34	39,000	−56	8500	4–2
	d	10925–11275	July 18	19:14, 19:48	39,000	−56	8500	4–2
5.	B5 a	11275–11624	July 18	19:37	39,000	−56	8500	4–2
	b	11275–11624	July 18	19:51	39,000	−56	8500	4–2
	c	11624–11958	July 18	19:40	39,000	−56	8500	4–2
	d	11624–11958	July 18	20:02	39,000	−56	8500	4–2
6.	B6 a	11958–12264	July 18	20:05	39,000	−56	8500	4–2
	b	11958–12264	July 18	20:15	39,000	−56	8500	4–2
	c	12264–12560	July 18	20:08	39,000	−56	8500	4–2
	d	12264–12560	July 18	20:18	39,000	−56	8500	4–2, 4-3
7.	B7 a	12560–12844	July 19	18:26	39,000	−54	8500	5–1
	b	12560–12844	July 18, 19	20:21, 18:47	39,000	−55	8500	4–3, 5–1
	c	12844–13121	July 19	18:29	39,000	−54	8500	5–1
	d	12844–13121	July 19	18:50	39,000	−53	8500	5–1
8.	B8 a	13121–13387	July 19	18:32	39,000	−54	8500	5–1
	b	13121–13387	July 19	18:53	39,000	−53	8500	5–1
	c	13387–13642	July 19	18:35	39,000	−54	8500	5–1
	d	13387–13642	July 19	18:56	39,000	−53	8500	5–1
9.	B9 a	13642–13887	July 19	18:59	39,000	−53	8500	5–2
	b	13642–13887	July 19	18:38	39,000	−54	8500	5–1, 5–2
	c	13887–14098	July 19	19:02	39,000	−53	8500	5–2
	d	13887–13994	July 19	18:41	39,000	−54	8500	5–2

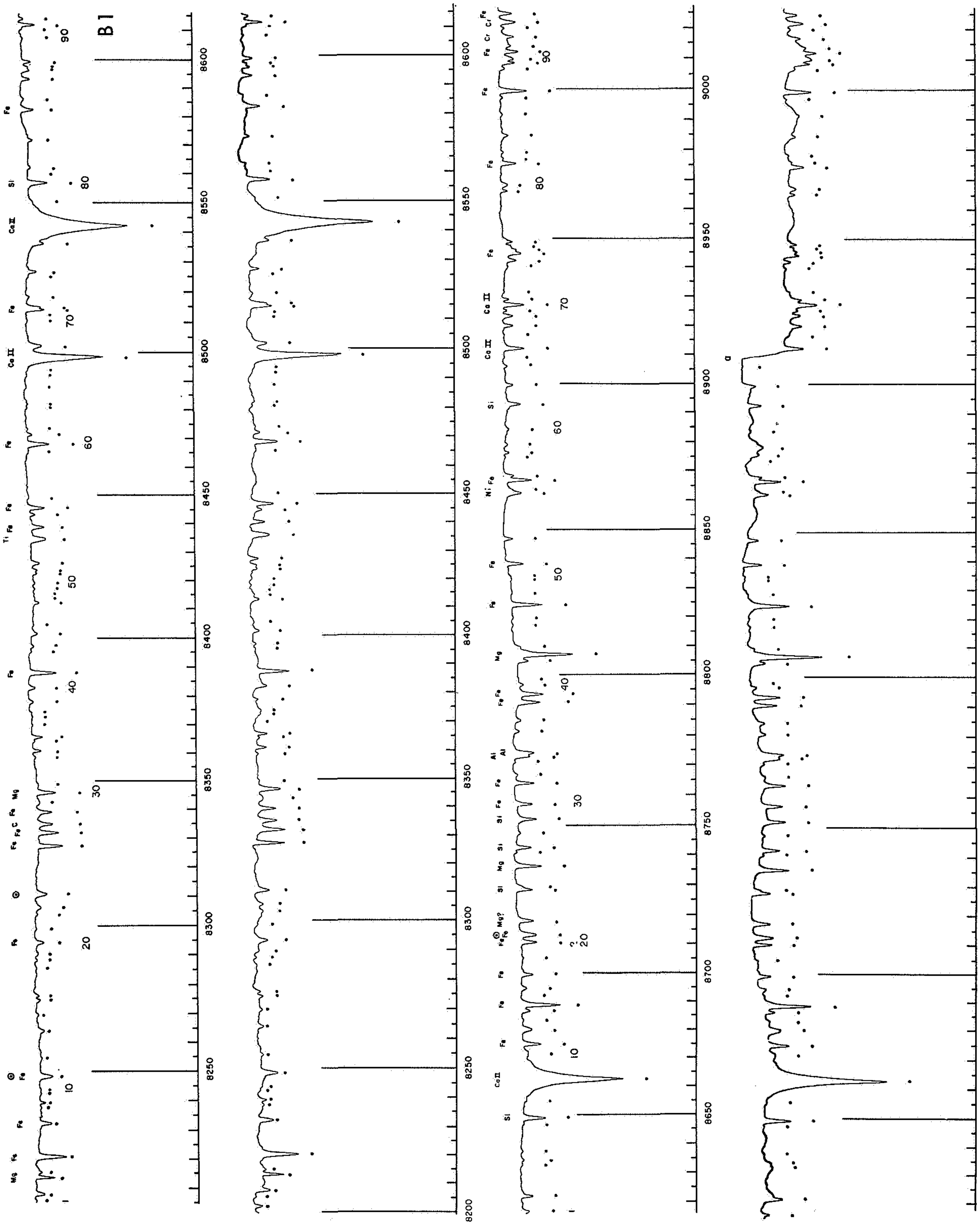

Fig. 1 B-spectrometer record of solar spectrum λλ8199–9025. "a" is slit length changed.

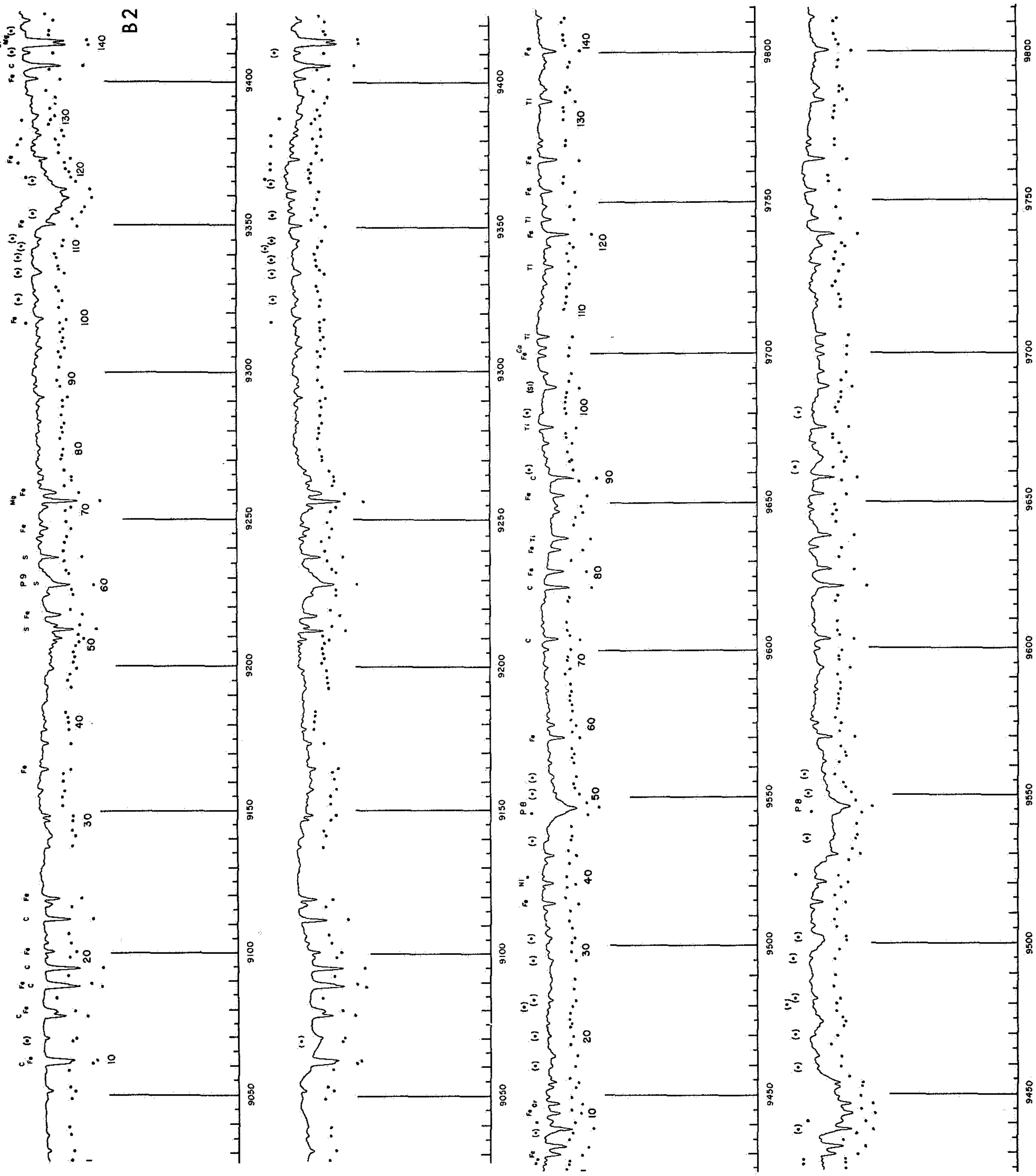

Fig. 2 B-spectrometer record of solar spectrum λλ9025–9815.

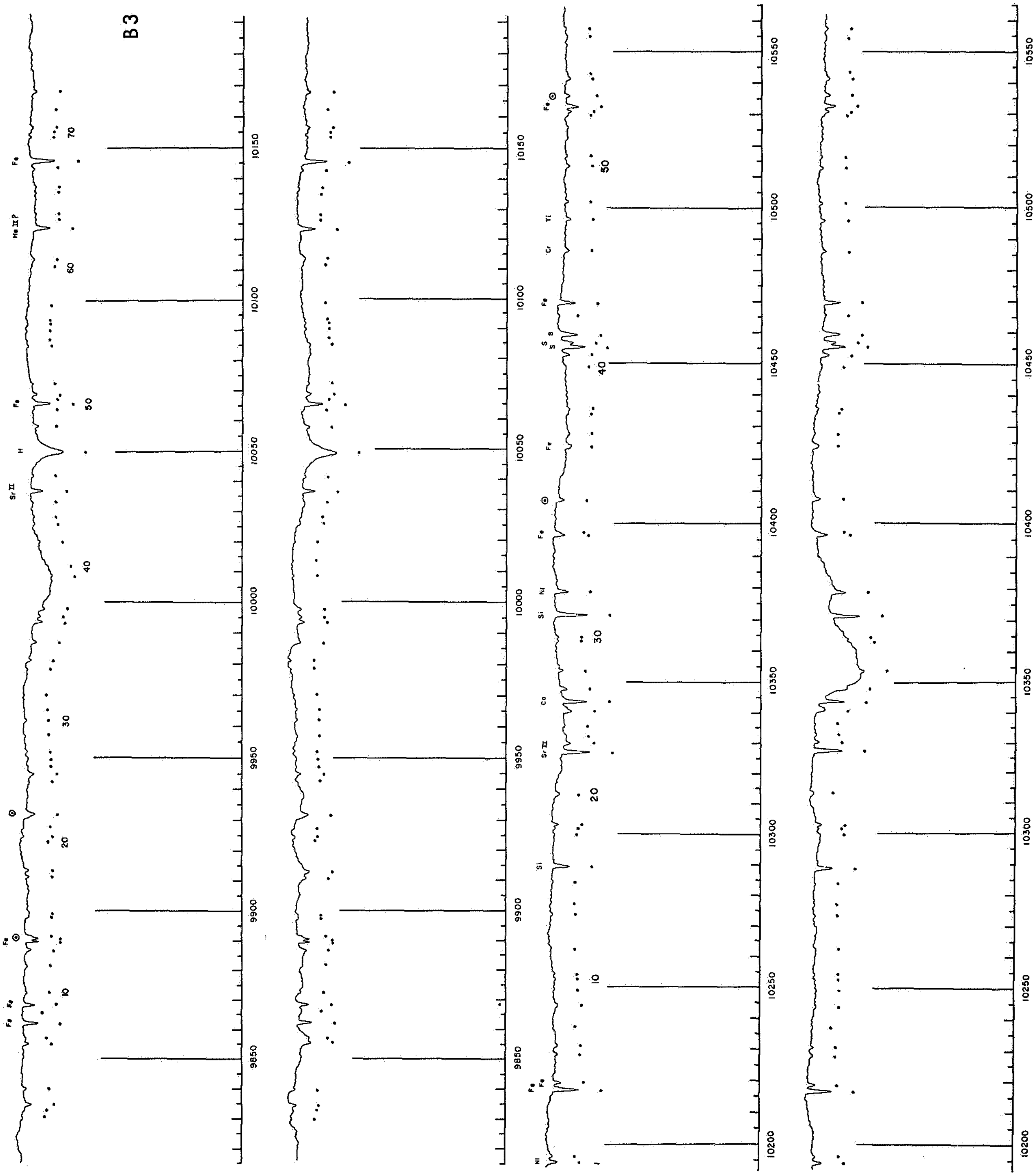

Fig. 3 B-spectrometer record of solar spectrum λλ9815–10565.

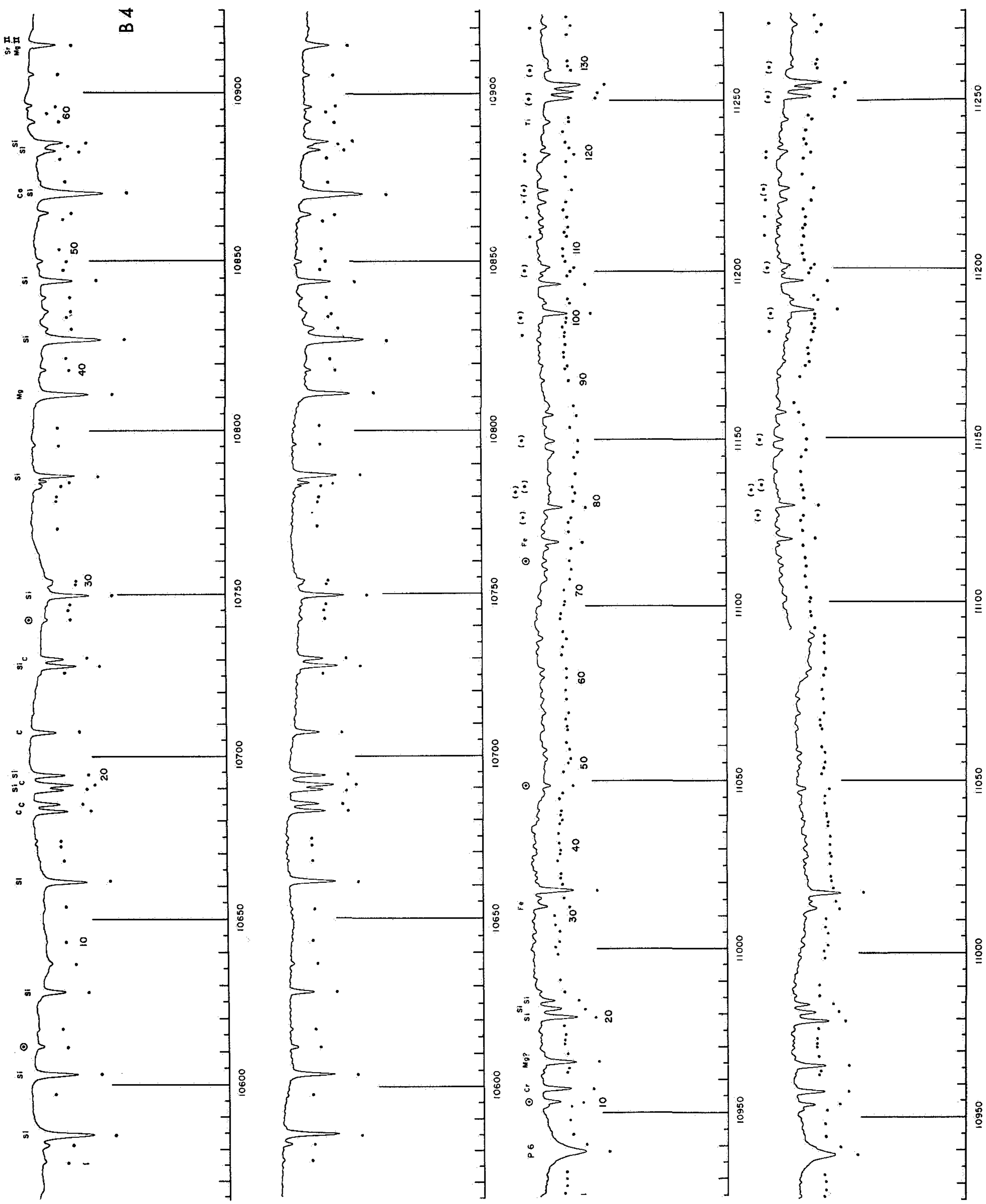

Fig. 4 B-spectrometer record of solar spectrum λλ10565–11275.

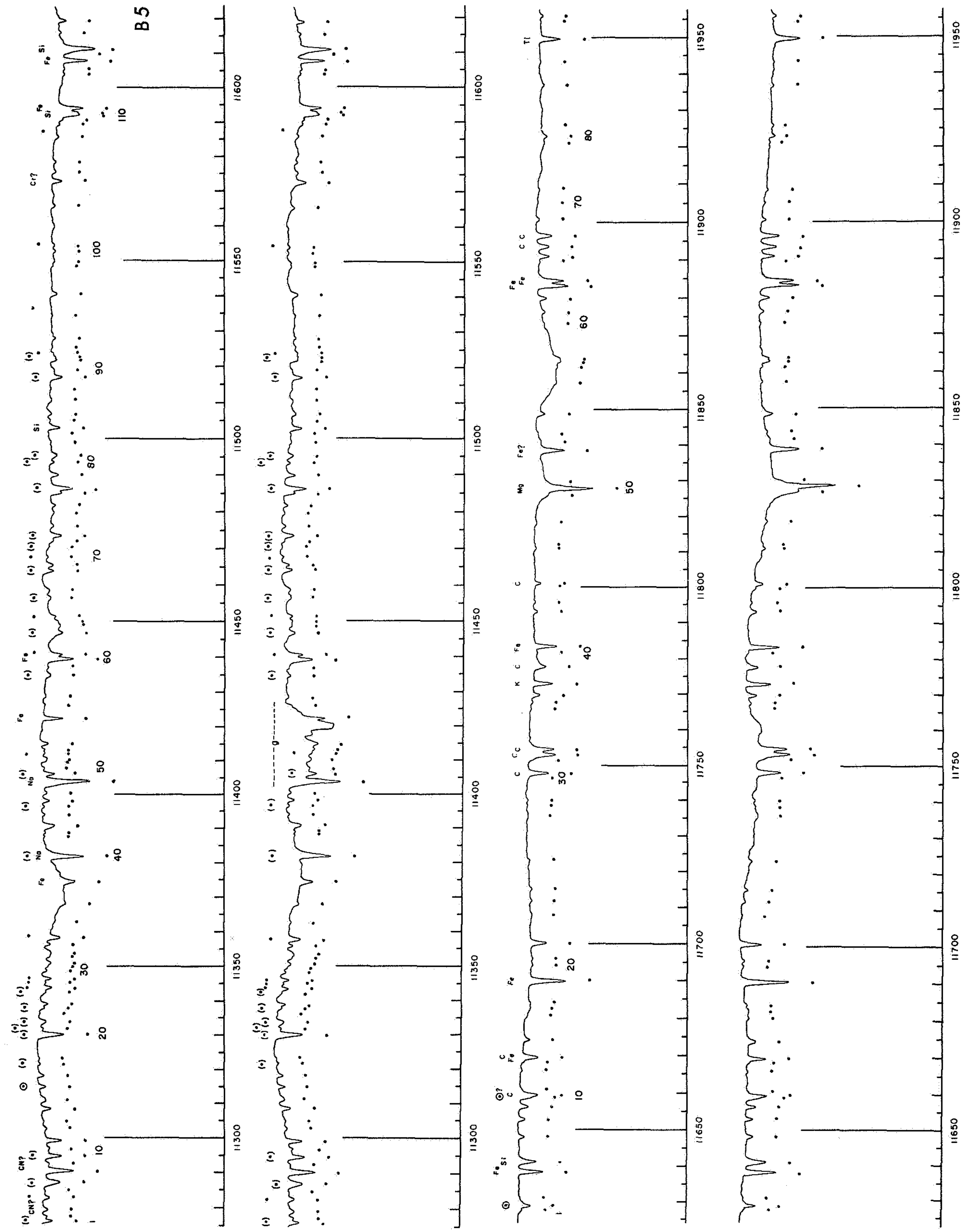

Fig. 5 B-spectrometer record of solar spectrum λλ11275–11958.

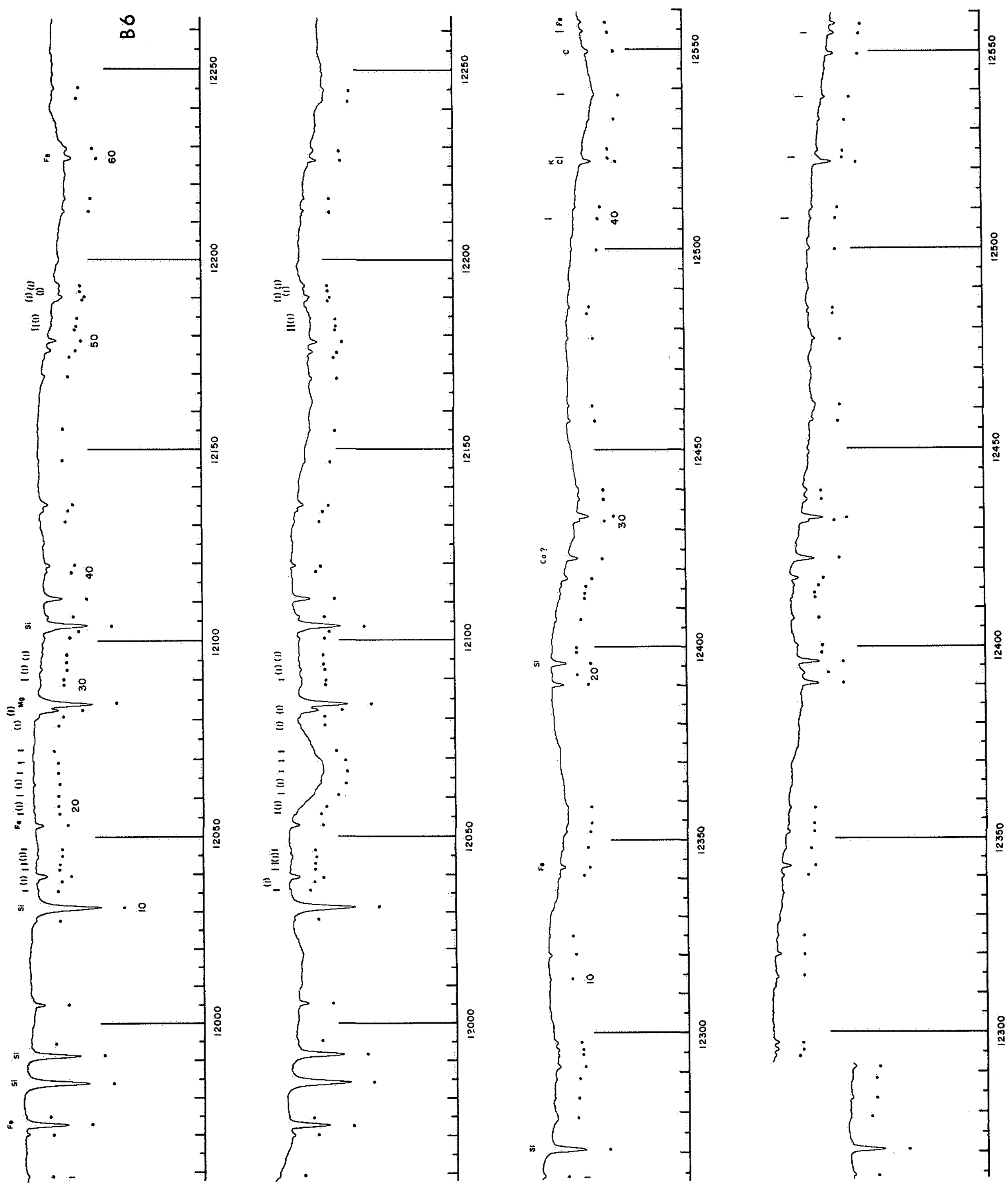

Fig. 6 B-spectrometer record of solar spectrum λλ11958–12560.

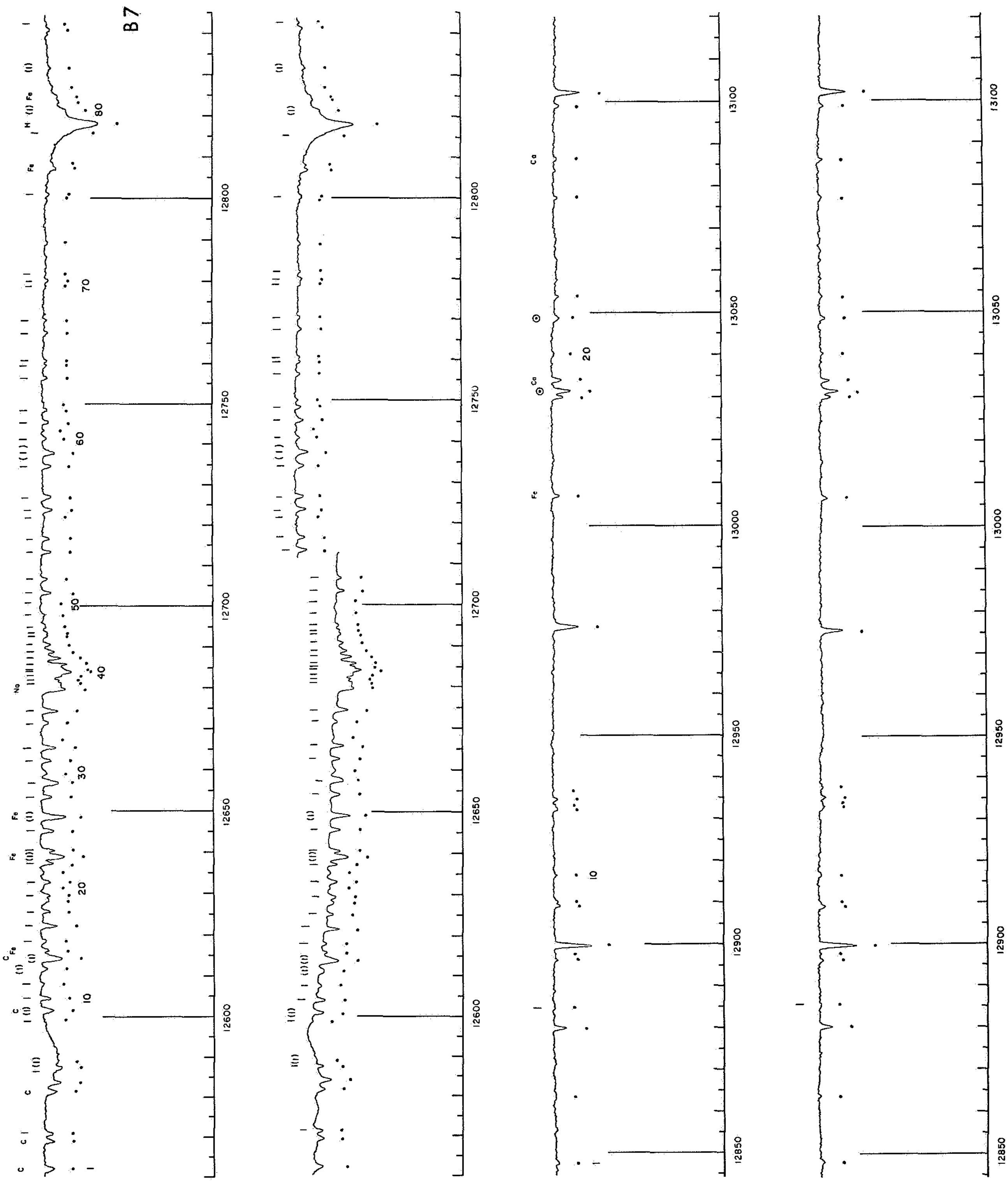

Fig. 7 B-spectrometer record of solar spectrum λλ12560–13121.

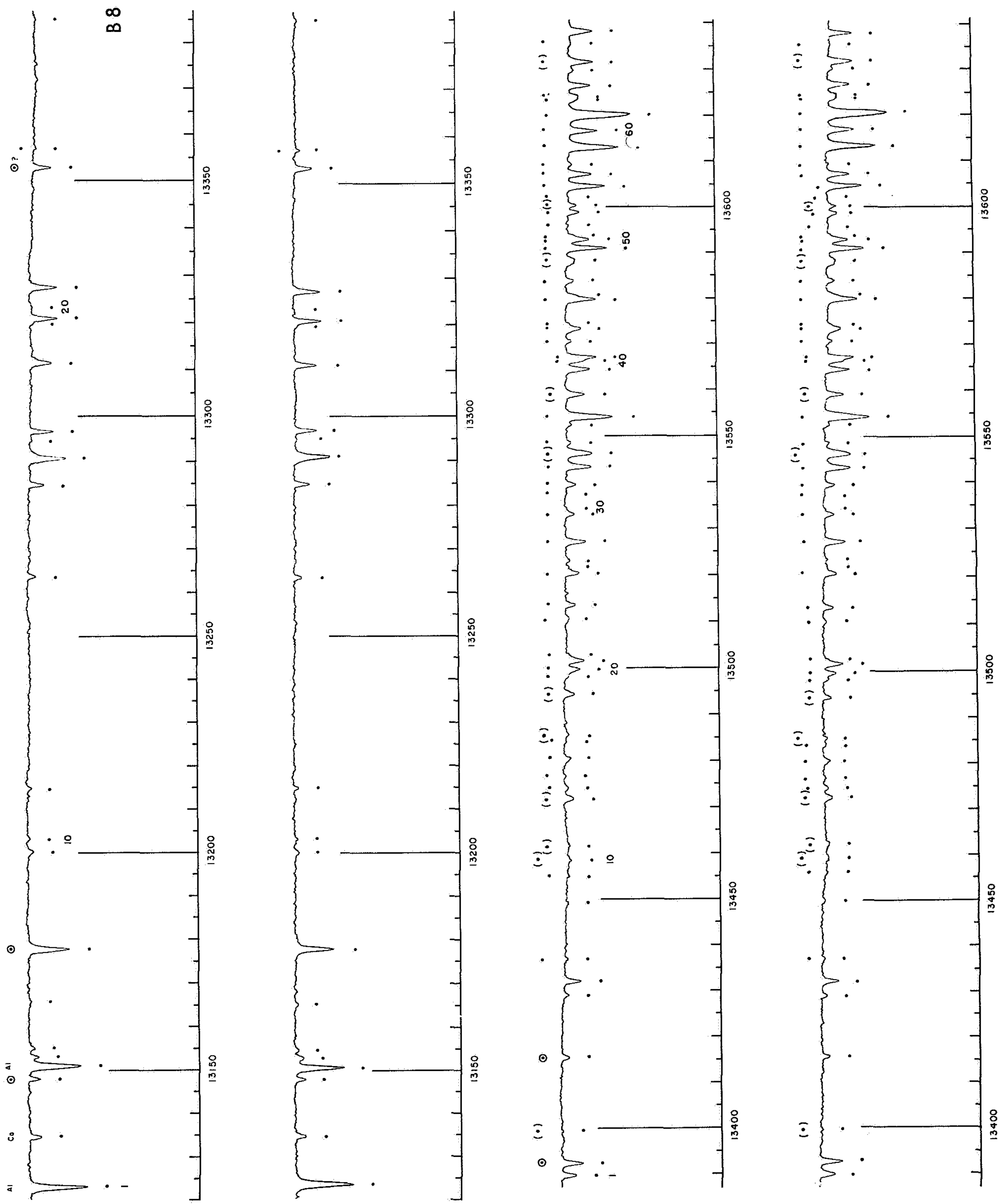

Fig. 8 B-spectrometer record of solar spectrum λλ13121–13642.

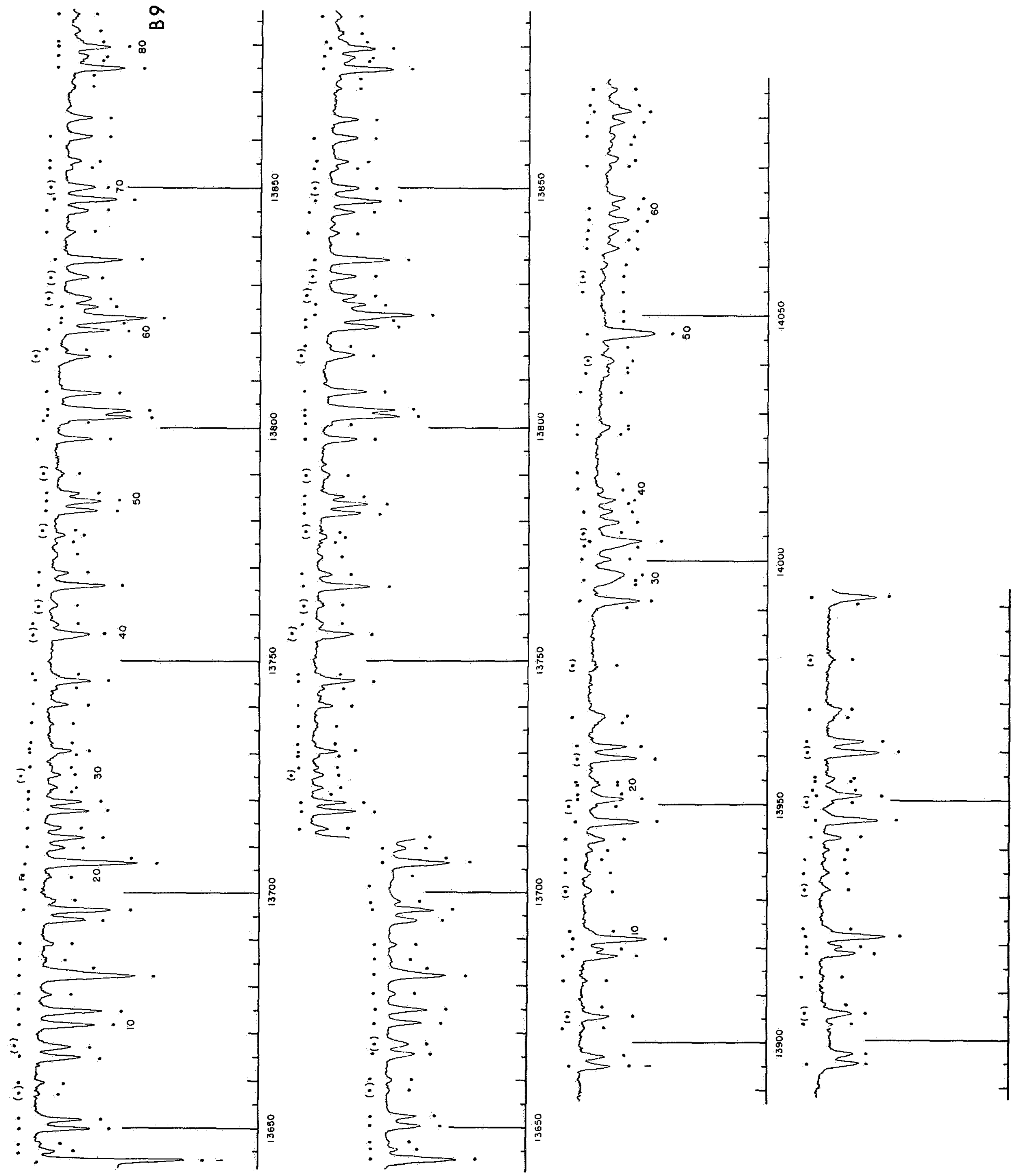

Fig. 9 B-spectrometer record of solar spectrum λλ13642–14098.